FERRIC CHLORIDE LEACHING OF SULPHIDE MINERAL CONCENTRATES
PHASE II
FINAL REPORT

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& ASSOCIATES LTD.

VANCOUVER, B.C. CANADA

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CONTRACT SERIAL NO. 0SQ84-00290
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Mineral Development Agreement

June 1985

TITLE: Ferric Chloride Leaching of Sulphide Mineral Concentrates - Phase II

FINAL REPORT
BY

Bacon, Donaldson & Associates Ltd.
June 1985

Work on this project was conducted under the auspices of the Canada Centre for Mineral and Energy Technology, Energy, Mines and Resources, Canada.

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CANMET SCIENTIFIC AUTHORITY: Mr. B. H. Lucas

BDA PROJECT NUMBER: 5371

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Mr. B. H. Lucas
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Dear Sir

Re: DSS File No. 23SQ.23440-4-9202
Contract Serial No. 0SQ84-00290
BDA Project No. 5371

Please find enclosed one original and twelve copies of the final report entitled "Ferric Chloride Leaching of Sulphide Mineral Concentrates - Phase II".

We trust that this report fulfills all your requirements as outlined in the request for proposal and our subsequent discussions. If additional questions arise we are prepared to discuss them with you.

The laboratory test program has been carried out under the direction of Mr. Rein Raudsepp. The pilot plant size estimates and costing has been carried out under the direction of Mr. Alan Childs.

It has been a pleasure working on this project and we hope our efforts assist you in continued development of the CANMET process.

Yours truly
BACON, DONALDSON & ASSOCIATES LTD.

M Beattie

Dr. M. J. V. Beattie, P.Eng.
MJVB/ls

FERRIC CHLORIDE LEACHING OF SULPHIDE MINERAL CONCENTRATES
PHASE II

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SECTION 1
EXECUTIVE SUMMARY

1. Each of the unit operations in the CANMET ferric chloride process flowsheet have been tested on a laboratory scale. The parameters to be used for each operation were either provided by CANMET or were developed as part of the present test program.

2. The leaching circuit which has been adopted for the pilot plant is a modified version of the CANMET two stage leach. The modified leach utilizes three stages of leaching having the same solids retention time but requiring less retention volume than the two stage leach. At the same time, better control is achieved over residual ferric in cementation feed and over metal extraction. The extractions achieved, using the three stage circuit are as follows:

Lead	99.5%
Zinc	99 %
Copper	93.5%
Silver	93 %

   The solubilization of iron and sulphate during leaching appears to be strongly dependent on the degree of superficial oxidation of the concentrate.

3. Chlorination of recycle solutions is very effective at regenerating ferric with almost complete utilization of chlorine.

4. The cementation of copper and silver from solution using lead powder has been demonstrated. The residual silver in solution was less than 1 ppm but the residual copper in

solution was 8 ppm. The residual copper concentration appeared to be sensitive to the degree and duration of agitation for cementation.

Continuous pilot scale testing will be required to confirm the effectiveness of cementation.

5. Cooling of the leach solution following cementation is effective at crystallizing lead chloride from solution. Post crystallization from solution was not observed. The lead chloride crystals are very friable and break readily, resulting in a fine size distribution. Several alternative crystallization strategies are envisaged for the pilot plant in order to optimize the crystallization procedure.

6. The solvent extraction of zinc from the chloride leach solution has been demonstrated on a continuous basis using a TBP-Solvesso mixture. The circuit operated well on a continuous basis but indicated that a high circulating load of zinc would be experienced using the parameters provided by CANMET. Possible modifications to the process conditions which will reduce the circulating load of zinc should be established and tested.

7. The loaded strip solution produced by solvent extraction has a high impurity content. The use of zinc oxide-zinc cementation for impurity control has been tested. The resultant solutions still contain lead and copper at concentrations that are higher than is desirable. Additional purification studies should be undertaken.

8. Turboaeration of the raffinate from zinc solvent extraction is effective at oxidizing the solution and precipitating iron from solution. Since only a small degree of oxidation of the solution is required and the precipitation of iron is

not desirable, the turboaeration circuit should be operated accordingly.

9. A flowsheet has been established for a pilot plant capable of treating 10 kg. per hour of concentrate on a continuous basis. The flowsheet and a mass balance for the flowsheet have been based on data developed from the laboratory test program.

10. Equipment has been selected, sized and costed for piloting the CANMET Lead-Zinc process at a throughput of 10 kg. per hour. The installed cost for the pilot plant is $985,369. to an accuracy of ± 10%.

Resume Executif

1. Chaque opération unitif dans le procédé au chlorure de ferrique de CANMET était éprouvé à l'echelle du laboratoire. Les paramétres du procédé qui ont été utilises pour chaque opération ont été préparés par CANMET ou ont été développés pendant l'investigation au présent.

2. Le circuit de lessivage qui a été adapté pour l'usine-pilote est une version modifiée du lessivage avec deux étages de CANMET. Le lessivage modifié utilisait trois étages qui a la même rétention du solide que le lessivage avec deux étages a, mais le volume de la rétention dans le lessivage avec trois étage est moindre que le lessivage avec deux étages. En même temps, la conduite du fer (III) résiduel dans l'alimentation de la cémentation et l'extraction des métaux sont meilleurs. Les extractions achevés qui utilisent le circuit avec trois étages sont:

Plomb	99.5 %
Zinc	99 %
Cuivre	93.5 %
Argent	93 %

La dissolution du fer et du sulfate durant le lessivage apparaît surtout à compter du degré d'oxydation superficiel dans la concentrate.

3. La verdunisation de la solution recyclique est très effective pour reproduire le fer (III) et l'utilisation du chlore est presque complet.

4. La cémentation du cuivre et de l'argent de solution utilisant la poudre de plomb était demontré. L'argent résiduel dans la solution était moins que 1 ppm, mais le cuivre résiduel dans la solution était 8 ppm. La concentration du cuivre résiduel apparaît à compter du degré et de la durée de l'agitation pour la cémentation. Une usine-pilote continu sera nécessaire pour confirmer l'efficacité de la cémentation.

5. Le rafraîchissement de la solution de lessivage est effectif pour la cristallisation du chlorure de plomb. La post-cristallisation dans la solution n'était pas observée. Les cristaux du chlorure de plomb sont très friables et brisent facilement, aboutissant a une distribution de dimension fines de cristaux. Plusieurs stratégies pour la cristallisation sont possibles dans l'usine-pilote pour optimiser le procédé de cristallisation.

6. L'extraction de solvant de zinc de la solution au chlorure était demontré en une façon continue utilisant un mélange de TBP-Solvesso. Le circuit opérait bien mais il a montré que une charge forte en zinc pourrait circuler utilisant les paramètres reçus de CANMET. Les modifications du procédé qui reduira la charge ciculant de zinc devra être établi et éprouvé.

7. La solution chargée dépouillant qui produisait par l'extraction de solvant a un niveau haut des impuretés. L'utilisation de la cémentation avec l'oxyde de zinc/zinc ont été éprouvée. La solutions qui était produit contien encore un niveau de plomb et cuivre qui est trop haut. Plus d'études de l'épuration devrons être faites.

8. La turboaeration du raffinage de l'extraction de solvant est effectif pour l'oxydation de la solution et la précipitation du fer de la solution. Puisque un peu de degré

d'oxydation est nécessaire et la precipitation du fer n'est pas désirable, le circuit de turboaeration devra operé en conséquence.

9. Un dessein pour l'usine-pilote continu de 10 kg/h ont été établi. Le dessein et une balance de matières ont été fondées sur les travaux du laboratoire.

10. Les équipement ont été établis et le coût ont été evalué pour une usine-pilote de 10 kg/h du procédé de plomb-zinc de CANMET. L'investissement en capital pour l'installation de l'usine-pilot chiffrait à 985 369 $ (± 10%).

RECOMMENDATIONS

A pilot plant utilizing the CANMET ferric chloride process to treat 10 kilograms per hour of concentrate on a continuous basis has been designed and costed. The flowsheet for the pilot plant utilizes parameters for each of the unit operations as provided by CANMET or as developed as part of the present program. Prior to conducting the pilot plant program there are several aspects of the process which should be given further consideration. These are as follows:

1. Both solvent extraction and turboaeration result in process solutions which are free of acid. Thus, while the proposed flowsheet calls for leaching to be done with a solution containing 0.43 M HCl, this would require the continuous addition of acid to the leach. A more viable alternative may be to operate the entire process under neutral conditions. It should be confirmed that operating the process in this manner is feasible.

2. Turboaeration of the solution from solvent extraction prior to chlorination should not be done to the point of iron rejection. The material balance for the process has revealed that there is a net deficiency of iron due to bleed stream requirements to maintain a water balance. It should be determined whether turboaeration as a distinct unit operation is justified or whether the introduction of a small addition of oxygen to the second stage leach would result in sufficient oxidation to meet the requirements of the process.

3. The operation of the zinc electrowinning circuit at 15 g/l Zn results in a high zinc concentration in the raffinate from zinc solvent extraction. This in turn leads to a high circulating load of zinc in the process. Testwork should be done with lower zinc concentrations in electrowinning to determine whether this is economically feasible and to confirm that this will decrease the circulating lead of zinc in the process.

4. The current flowsheet for the process calls for the electrowinning of zinc in a diaphragm cell while producing chlorine at the anode. The chlorine is used subsequently to oxidize the iron in the leach solutions. It could be feasible to electrowin the zinc in a membrane cell while oxidizing iron at the anode. This would decrease the need to handle chlorine and should decrease the potential required in electrowinning. An analysis should be done as to the comparative economics of these two electrowinning strategies.

5. The discussions with CANMET have revealed that the process to be used for the recovery of lead from lead chloride has not been finalized. This part of the circuit should be established prior to piloting of the process since it could influence the requirements for lead chloride crystallization. If fused salt electrolysis is chosen as the method for lead recovery, purification fo the lead chloride crystals by recrystallization should be investigated.

SECTION 2
STATEMENT OF WORK

2.1 Introduction

The recovery of metals such as zinc, copper lead, silver and nickel from complex ores is complicated by losses of values into smelter grade concentrates of another metal; e.g. silver losses into zinc concentrates. Frequently these losses represent a wasted resource. Canada is interested in conserving its resources. Furthermore, pyrometallurgical treatment of sulphide ores has been identified as one source of acid rain. CANMET has been evaluating hydrometallurgical processes to assess their ability to conserve both energy and the environment while remaining commercially viable.

One process which CANMET has been considering is the use of ferric chloride leaching. Phase I of the program to evaluate the use of ferric chloride leaching was awarded to Acres Davy McKee Engineering Inc. acting as the main contractor with the Ontario Research Foundation acting as subcontractor. The objective of Phase I was to assess fully the process of ferric chloride leaching of complex sulphide concentrates with respect to its feasibility.

Subsequent to the Phase I study, CANMET carried out bench scale testwork to establish parameters for certain unit operations. Phase II of the study was designed to accelerate the development of the ferric chloride leaching process by carrying out supplemental bench scale testwork and by designing a 10 kg. concentrate per hour continuous pilot plant.

Phase II of the program was awarded to Bacon, Donaldson & Associates Ltd. as the prime contractor. All bench scale testwork to develop and confirm parameters for the pilot plant was carried out in the laboratories of Bacon, Donaldson & Associates Ltd. The design and costing of the continuous pilot plant was carried out by Stearns Catalytic Ltd.

2.2 Scope of Work

The objectives of Phase II of the program can be summarized as follows:

1. To confirm parameters for certain unit operations.
2. To develop parameters for other unit operations.
3. To select suitable equipment, size, select material of construction and cost equipment for a 10 kg. concentrate per hour continuous pilot.

The following represents the work that has been undertaken in order to satisfy the objectives.

Parameters which were supplied by CANMET entitled "CANMET $FeCl_3$ Leach Process" are attached as Appendix A. In addition, some parameters such as those for solvent extraction were received verbally during the program.

2.2.1 Leaching

Parameters were given by CANMET for a two-stage ferric chloride leach operation. Under the prescribed conditions the respective extractions of lead, zinc, copper and silver were to be at least 99.5, 98.3 and 91.6 percent. At the same time the pregnant solution for cementation treatment was to contain the minimum possible ferric concentration. Tests conducted by CANMET had produced solutions containing 0.0 to 1.3 g/l Fe^{3+}. Leaching was carried out in 15 litre batches to produce solutions and residues for testing of subsequent unit operations as well as to confirm the leach parameters. Some variability in leaching results was experienced and a modified leach procedure was adopted. The modified three stage leach procedure has the dual advantage of achieving the desired results while requiring a greatly reduced leach volume.

Additional leaching testwork was performed to observe the effects of sulphate removal and regrinding on leach performance.

2.2.2 Leach Slurry Solid-Liquid Separation

The slurry from each of the three leach stages must be thickened for solid-liquid separation. In addition, the third stage leach residue has to be filtered and washed to produce a final residue for disposal.

Settling tests were carried out on each of the leach discharge slurries with and without the addition of settling agents. It was determined that the solids settled rapidly and that the real concern in settling was the conditions required to obtain a clear supernatant solution. Therefore, clarification studies were carried out on leach discharge slurries.

Filtration tests were carried out on the leached residue to establish the requirements for achieving a final residue with very low dissolved metal content. The effects of repulping between wash stages and of wash conditions were studied. Physical properties of the leach residue were obtained.

2.2.3 Lead Powder Cementation

Tests were carried out on lead powder cementation of copper and silver according to parameters established by CANMET. Initial tests carried out with reagent grade lead powder obtained from one supplier were completely unsuccessful in cementing out copper and silver. Testwork performed with lead from an alternate supplier gave the results predicted by CANMET testwork and the program was completed with this material.

The quantity of cement product produced in bench scale testwork is very small and studies relating to the filtration and washing of this product will not be meaningful until greater quantities are produced by continuous pilot testing of the process.

2.2.4 Lead Chloride Crystallization

Following cementation, the solution must be cooled in order for lead chloride crystallization to occur. Temperature-solubility curves have been developed to demonstrate the concentration of dissolved lead to be achieved by cooling to temperatures down to 10°C.

Tests were done using varying cooling procedures and rates to observe the effects on crystal size. Washing of the resultant lead chloride crystals has been studied.

The pilot plant has been designed with sufficient flexibility that various cooling procedures and conditions can be evaluated.

Following discussions with CANMET it was determined that drying of the lead chloride crystals was not of concern. Drying studies have therefore not been performed.

The pilot plant will be provided with batch drying capability so that both wet and dry crystals can be produced for lead recovery studies.

The lead chloride crystals settle rapidly and filter very well. It is therefore envisaged that direct filtration of lead chloride will be performed followed by several stages of washing. The effect of washing on crystal purity has been studied.

2.2.5 Zinc Solvent Extraction

The basic parameters for solvent extraction such as solvent to be used, organic to aqueous ratios and number of stages of extraction and stripping were supplied by CANMET. Using these basic parameters a series of continuous tests was carried out to confirm the zinc concentrations which could be achieved in the various streams. Samples were taken of the loaded strip solution to determine the concentration of impurities which would report to zinc electrowinning. Zinc dust cementation has been used to produce a final solution.

2.2.6 Zinc Electrowinning

No zinc electrowinning studies were to be performed as part of the present program. CANMET have performed detailed electrowinning studies in the past and criteria developed as a result of those studies have been used for pilot plant design.

2.2.7 Oxidation of Recycle Liquor

Oxidation of recycle liquor by turboaeration has been studied to observe the rate of ferrous oxidation to ferric and the removal of iron from solution. As discussed with CANMET, these tests were performed at elevated temperatures (90°C) and with oxygen. The settling and filtration of the precipitate formed in this operation have been studied.

2.2.8 Chlorination of Recycle Liquor

Two streams in the flowsheet are to be chlorinated. The solution from the second stage leach is to be chlorinated before being introduced into the first leach stage. The recycle stream from solvent extraction is to be chlorinated before being introduced into the second leach stage.

Initial testwork was performed with a countercurrent column absorption reactor. These tests showed the chlorination to be very effective at oxidizing the ferrous in solution to ferric. Following discussions with CANMET and Stearns Catalytic it was determined that a co-current reactor was being employed at CANMET and that the most reasonable design for the pilot plant was a series of agitated tanks. Some testwork therefore was performed therefore to determine the rate of chlorination in a stirred vessel.

2.2.9 Sizing and Costing of Pilot Plant

A pilot plant has been sized to treat 10 kg. concentrate per hour on a continuous basis. The parameters for pilot plant design were obtained from CANMET in some cases and were developed from the laboratory test program in other cases. All parameters to be used for design of the pilot plant were agreed on in a meeting between CANMET, Stearns Catalytic Ltd. and Bacon, Donaldson & Associates Ltd. in Ottawa on February 20 and 21, 1985.

Materials of construction for the plant were also discussed at that meeting and appropriate selections have been made.

In the design of the pilot plant only the unit operations were costed. The design and costing of a building to house the plant is not included. It is assumed that the pilot project will be contracted out to an organization with appropriate facilities.

SECTION 3

BENCH SCALE TESTWORK

3.0 Summary of the Results

3.0.1 Leaching

The flowsheet for the CANMET ferric chloride process involved a two-stage countercurrent leach with a 1st stage batch time of 180 minutes and a 2nd stage batch time of 270 minutes. The results of the present test program indicated that the initial leaching rates of the sulphide minerals were very high. The 180 minute residence time of the first stage leach was determined to be excessive because the solution became reduced rapidly and then further leaching stopped. Zinc and silver required long leach residence time in the presence of excess ferric in order to achieve high levels of extraction.

A modified leach circuit flowsheet was tested to utilize the above features. The modifications to the flowsheet included:

1. Decreasing the first stage leach residence time to 45 minutes.
2. Decreasing the second stage leach residence time to 90 minutes.
3. Adding a third stage leach with a residence time of 300 minutes at a higher solids density than the first two stages of leaching.

This modified leach circuit required less volume than the original circuit because much of the residence time was achieved at increased solids density. An additional thickener is required for the new circuit but the cost of this thickener is offset by the decreased leach tank requirement and the increased extraction of zinc and silver. In order for the third stage leach to be effective, it should be operated with a high excess concentration of ferric over that required for leaching. It is proposed that the third stage would utilize ferric solution from chlorination in parallel with the second stage and that the third stage product solution would go to the second stage.

Table 3.0.1 summarizes the stagewise metal extractions to be achieved with the three stage leach circuit. Table 3.0.2 summarizes the calculated solids assays at each stage of extraction.

TABLE 3.0.1
Stagewise Metal Extraction in Leach Circuit

Leach Stage	Leach Time (min)	Extraction (%) Pb	Zn	Cu	Ag
1	45	99	60	40	60
2	90	50	85	80	60
3	300	0	75	40	50
Overall		99.5	99	93.5	93

TABLE 3.0.2
Solids Assays at each Stage in Leach Circuit

Leach Stage	Relative Weight	Residue Assays Pb %	Zn %	Cu %	Ag %
Conc.	1.000	8.80	28.60	0.80	218
1	0.636	0.13	18.00	0.70	138
2	0.527	0.08	3.26	0.18	67
3	0.513	0.08	0.83	0.11	34

In addition to achieving a portion of the overall metal extraction, the first leach stage must produce a reduced solution, suitable for feed to the Cu/Ag cementation circuit. It was determined that by adding 90% of the feed concentrate at the start of the first stage leach and the remaining 10% of the concentrate after 30 minutes out of the total of 45 minutes that a residual ferric concentration of 0.09 g/l could be achieved.

The mean measured increase of iron in solution during leaching was 5 g/l. The calculated increase based on the iron in marmatite and chalcopyrite should be 3.9 g/l. It is believed that the increased iron dissolution over the calculated value results from concentrate oxidation prior to use.

The mean incremental sulphate increase in solution was approximately 12 g/l. Over 90% of this sulphate results from sulphate present in the feed concentrate. The remaining sulphate is formed during leaching.

Pretreatment of the concentrate by regrinding or washing with a sodium sulphide solution did not improve the leach kinetics. Both these measures did remove sulphate from the concentrate and therefore minimized the increase in sulphate in solution during subsequent leaching.

It was determined that the first stage leach solution was not susceptible to oxidation by air. Stirring of a hot solution exposed to the air for five hours did not result in a significant oxidation of ferrous to ferric.

3.0.2 Leach Residue Settling

The slurries from all the leach stages settled quickly with ultimate settled solids densities in the order of 50 to 60% (data from the leach test sheets). The supernatant solids concentration was approximately 0.5 g/l. The leach slurries tended to form stable foams and sprays will be required in the thickeners.

3.0.3 Residue Filtering

The third stage settled solids filtered and washed very rapidly with each step usually requiring only a few seconds. With a slurry: wash ratio of 2:1 over 99% of the dissolved solids were removed with two hot 1 M NaCl washes followed by a hot water wash.

Although the testwork was carried out with vacuum filtration, it is expected that a continuous operation would use pressure filtration as the solutions are very close to their boiling point. Polypropylene filter cloths were tested, however, under pressure at the operating temperatures it is expected that Kynar cloths would probably have better long term stability.

3.0.4 Chlorination

Chlorination of the 2nd stage leach solution proceeds easily in an agitated tank with chlorine being dispersed into solution by means of a submerged frit, over 90% iron oxidation was achieved before residual chlorine was detected in the gas phase over the tank. 13.8 l of solution were chlorinated in 21 minutes at the rate of 1.72 g Fe^{3+}/l. min. Gas-phase continuous column chlorination was less effective.

3.0.5 Copper-Silver Cementation

The majority of the silver in the 1st stage solution was cemented from solution quite rapidly using lead powder; a drop from 32 to 0.6 ppm was observed in 15 minutes using 5 g/l Pb. However lower levels were not reached. Copper was more persistent and required further lead addition.

With only lead additions the minimum copper concentration which was achieved was 8 ppm. With antimony added to solution as well as the lead dust, a copper concentration of 5 ppm was achieved. The decrease in dissolved copper in the presence of antimony is not considered to be dramatic enough to warrant the addition of the antimony. Variations in procedure should be considered instead. The copper concentration in solution was observed to "rebound". This effect was concluded to result from the re-dissolution of cement copper that has stripped from the lead powder. Varying the degree of agitation during cementation resulted in variations in the degree of re-dissolution. Until cementation is performed on a continual pilot-scale, the true levels of copper and silver to be achieved in cementation will not be known. If the levels achieved at that time are too high, consideration should be given to a two stage cementation with filtration between the stages.

3.0.6 Lead Chloride Crystallization

Lead chloride solubility is a function of temperature and chloride concentration. Cooling the leach solution to 15°C gives a lead concentration of approximately 9 g/l. A 1 litre crystallizer was used for the first part of the work and then discontinued as only fine crystals (60-90% - 400 mesh) were produced regardless of conditions. A cooled leach test produced slightly larger crystals, particularly when slower cooling rates were used.

By cooling from 100°C to 40°C in a heat exchanger and then cooling from 40°C in to 10°C over the period of one hour, crystals containing 13.5% -400 mesh were produced. The crystals appeared to be very friable and appeared to break when agitated or pumped.

The crystallization circuit for the pilot plant has been designed with the ability to recirculate the $PbCl_2$ crystals in order to promote crystal growth. It will have to be determined during pilot plant operation whether crystal growth does in fact occur or whether it is overshadowed by the effects of crystal degradation.

The production of large crystals is more desirable than the production of fine crystals because larger ones carry fewer impurities. The fine crystals produced in the present study were found to settle, filter and wash very well.

At the start of this program it was indicated that fused salt electrolysis was to be used for the recovery of lead from lead chloride. During the progress meeting in Ottawa with CANMET personnel it was revealed that aqueous electrowinning was the more likely treatment route. Impurities, particularly sulphate, are more detrimental to fused salt electrolysis than to aqueous electrowinning because there is no way for impurities to leave the fused salt electrowinning cell. The concentration of impurities in the crystals therefore became of less importance. Prior to piloting of the process, CANMET should confirm the lead chloride treatment route to be followed.

Crystals produced from solutions which had not been purified by cementation contained 0.46 to 0.64% SO4 whereas crystals produced from purified solutions contained as little as 0.01% SO_4.

It appears therefore that one of the elements removed during cementation resulted in sulphate precipitation during lead chloride crystallization if it was not removed prior to crystallization. Since it was not within the scope of the present program to conduct research into unexplained phenomena, this area was not further explored.

3.0.7 Solvent Extraction of Zinc

Solvent extraction parameters were received verbally from CANMET late in the test program and no variables were modified. As the testwork progressed, the apparatus was expanded from 3 stages of extraction and 4 stages of stripping to 3 stages of extraction, 1 stage of scrubbing and 5 stages of stripping.

The solvent extraction circuit operated well. Although a silica crud developed at the aqueous-organic interface of the extraction settlers, it did not interfere with phase separation.

Using the parameters provided by CANMET, the zinc content of the stripped organic remained at 12 - 15 gpl Zn. The raffinate zinc content therefore is also high, resulting in a large circulating load of zinc in the process. Consideration should be given to decreasing the zinc content of the strip solution which is derived from electrowinning and determining how this would affect zinc levels throughout the solvent extraction circuit.

The loaded strip solutions contained from 40 to 50 gpl Zn throughout the test program.

Although treatment of the loaded strip solution was not part of the present contract originally, it was recognized that the TBP/Solvesso extractant would result in high levels of Fe, Pb and Cu going to zinc electrowinning. At the request of CANMET, additional work was performed on the purification of the strip solution by means of cementation with ZnO and Zn dust. Although the iron in solution was reduced to less than 1 ppm, the lead remained at 5 ppm and copper remained at 6 ppm. Additional purification steps or a modification of the cementation used for the present study should be considered for the pilot plant.

It was observed that the zinc solvent extraction removed acid from the feed solution. The implication this has to the process will be discussed in the next section on turboaeration.

3.0.8 Turboaeration

Turboaeration with oxygen was found to be under mass transfer control. The effects of stirrer rpm, oxygen addition rate and temperature on the ferrous oxidation rate were demonstrated and were in agreement with a mass transfer controlled rate. However, the oxidation of solutions having the same apparent composition, in terms of the major elements which were studied in the present program, showed different oxidation rates under identical conditions. It is apparent that an unidentified chemical control is being exerted on the oxidation rate.

All the solutions used for the turboaeration studies were raffinate from solvent extraction studies. These solutions were all free of acid. Any acid that did remain in solution would be consumed by the oxidation process. Such solutions, free of acid, precipitate iron with continued oxidation. In 6 hours of turboaeration with oxygen, 50 of 55 g/l iron were oxidized and 29 g/l iron were precipitated. Since the material balance for the pilot plant had indicated that the bleed stream removes excessive iron from the circuit, the removal of additional iron during turboaeration is not desirable.

It should also be apparent that if iron does not have to be removed from the circuit by means of turboaeration, the need for this unit operation is minimal. In addition to the removal of iron, the turboaeration step results in oxidation of the raffinate from zinc solvent extraction prior to chlorination. The oxidizing power required for copper, silver, zinc and lead dissolution is provided by the chlorine streams from lead and zinc electrowinning. Turboaeration only has to provide the oxidation required for iron dissolution and sulphate formation during leaching. Very little oxidation of the solution by turboaeration should therefore be done and it should be done in such a way that the minimum possible iron precipitation occurs. This is most easily achieved by using a short retention time for turboaeration.

The solids which precipitate during turboaeration consist of basic iron and iron-sulphate compounds. The solids settled well using additions of Percol 156 to produce a supernatant having a solids concentration of 2 g/l. It is not expected that the solids would need a separate solids/liquid separation but rather that the turboaerator flow would be added to the 3rd stage leach thickener and the contained solids would subsequently be settled and filtered with the leach residue.

3.1 Concentrate

CANMET provided a complex sulphide concentrate produced from Brunswick Mining and Smelting Company ore. This material was riffled to provide representative 2436 g lots for the leaching studies. The concentrate was assayed and the results are presented in Table 3.1 along with assays provided by CANMET.

TABLE 3.1
Concentrate Analysis

	BDA	CANMET (Appendix A)	CANMET (Sample FC-2-66)
Zn (%)	28.6	28.1	28.99
Pb (%)	8.8	8.75	8.52
Cu (%)	0.80	0.78	0.72
Fe (%)	17.3	19.1	20.22
Total S (%)	35.78	35.0	34.50
SO_4/S (%)	1.52	1.51	1.64
Elem S (%)			0.33
K2 O (%)			<0.03
Mg O (%)			0.07
Ca O (%)			0.38
Ag (ppm)	218.4	233	233.5
Au (ppm)	0.686		
Insol (%)	1.30		

Table 3.2 presents the size analysis of the concentrate. The distribution for the concentrate as received and after two periods of regrinding are shown.

TABLE 3.2
Size Analysis of Concentrate

Size Fraction (mesh)	As Received wt. (%)	10 min. Grind wt. (%)	20 min. Grind wt. (%)
+65			
-65 +100			
-100 +150	0.23		
-150 +200	0.50		
-200 +325	1.99	0.30	0.26
-325 +400	0.46	1.42	0.89
-400	96.82	98.28	98.85

In order to calculate the mineralogy of the concentrate based on the analysis shown in Table 3.1, several tests were conducted to evaluate the degree of oxidation of the concentrate. The results presented in Table 3.3 are for two tests carried out under different conditions. Test A involved 50 grams of concentrate which was stirred with 500 ml of HCl solution (pH = 4) for 30 minutes at room temperature. Test B involved 50 grams of concentrate which was stirred with 500 ml of 20% HCl + 2 M NaCl solution for 30 minutes at boiling. The results indicate that the sulphate shown in Table 3.1 is in the acid soluble fraction. Therefore a sulphide sulphur content of 34.26% was used to calculate the mineralogy. The mineralogy calculation also assumes no pyrrhotite to be present and the marmatite to contain 5% mole fraction of iron. Copper has been assigned to chalcopyrite although minor tetrahedrite ($Cu_{12}(Sb, As)_4 S_{13}$) was found in the leach residue. The calculated mineralogy of the concentrate based on the BDA analysis in Table 3.1 is:

10.16 %	PbS
45.00 %	$Zn_{0.95} Fe_{0.05}S$
31.97 %	FeS_2
2.63 %	$CuFeS_2$
1.30 %	Acid insoluble
8.94 %	Acid soluble

TABLE 3.3
Acid Soluble Fraction of Total Solids

	Test A (%)	Test B (%)
Pb	3.85	8.20
Zn	1.4	2.0
Cu	<0.01	<0.01
Fe	0.044	0.066
S	1.52	1.86

3.2 Laboratory Test Results

The details of the tests which were done as part of this program are included as Appendix B. The procedures used for sampling and chemical analysis are included with Appendix B.

The results of tests done for each section of the flowsheet are summarized and discussed in the remainder of this section of the report. It should be noted that in reading through the section on leaching, D1 designates a first stage leach and D2 a second stage leach.

3.3 Concentrate Leaching

3.3.1 Progress of the Testwork

Prior to the start of testwork, verbal instructions were received that the lixivant solution should be changed from 3.5 M to 3.0 NaCl for the benefit of solvent extraction. Small scale leaches were then carried out as detailed to determine the exact quantitites of reagents required for 15 l batch leaches.

The initial large scale batch testwork (to Test D1-14 and D2-13) was done using the specified leach times of 180 min for the first stage and 270 min for the second stage. It was readily apparent that the initial rate of concentrate leaching was very rapid and so, the leach procedure was modified. Basically the leach times of the first and second stages were shortened and a third stage was added with a long residence time and a high solids density. In the first stage a small portion of the concentrate was added late in the leach to reduce the ferric iron in solution. Details of the leaches done are given in the following tables and include modifications used to study the effects of regrinding and sulphate control.

TABLE 3.4
Details of First Stage Leach Tests

Test No.	Total Conc Used (g)	Leach Time min and (% of concentrate added)	Notes
*12	2436	180 (100)	
13	2436	180 (100)	
*15	2436	60(90) + 15(10)	Conc. reground 10 min
*16	2436	60(90) + 15(10)	Conc. reground 20 min
17	2436	60(90) + 15(10)	Conc. reground 20 min
*18	2427	60(90) + 15(10)	Conc washed with Na_2S solution
19	2436	75 (100)	
*20	2436	60(90) + 15(10)	
21	2436	60(90) + 15(10)	
*22	2436	30(90) + 15(10)	
23	2436	30(90) + 15(10)	
24	2436	30(90) + 15(10)	299.4 $BaCl_2$ added to leach
25	2436	30(90) + 15(10)	
26	2436	30(90) + 15(10)	
27	2414	30(90) + 15(10)	Conc washed with pH4 solution
28	2438	30(90) + 15(10)	Conc washed with pH4 solution
29	2300	30(90) + 15(10)	
30	2300	30(90) + 15(10)	
31	2300	30(90) + 15(10)	

* leached with prepared lixivant, balance of tests used recycle solution from second stage leach.

TABLE 3.5

Details of Second Stage Leach Tests

Test No.	Leach Time (min)	% Lixivant from 3rd Stage	Notes
12	270	0	
13	270	0	
15	120	0	
16	120	0	
18	120	0	
20	120	0	
22	60	0	
23	90	16	
24	90	20	1/2 of HCl in lixiviant
25	90	22	no HCl in lixiviant
26	90	21	
27	90	24	
28	90	23	
29	90	0	no HCl in lixiviant
30	90	0	no HCl in lixiviant

TABLE 3.6
Details of Third Stage Leach Tests

Test No.	Leach Time (min)	Details
50(15)*	180	
51(16)	300	
52(18)	300	
53(20)	360	
55(22)	180	
56(23)	300	
57(24)	300	
58(25)	300	
59(26)	300	
60(27)	300	
61(29)	300	
62(30)	300	no HCl in lixiviant

* Numbers in brackets indicate second stage leach Test No. which provided solids for third stage leach.

3.3.2 Leaching Apparatus

Concentrate leaching was carried out on a batch basis in 18.5 l polypropylene tanks. Each tank was 30 cm in diameter by 30 cm deep and fitted with four 3.5 cm baffles and a bottom bearing. The impellers used were 14 cm in diameter with 4 blades 3 cm wide, set at 45°. The tanks were covered by tight-fitting lids with a removable section for reagent and concentrate addition. In use, each tank was heated by a 1000 W quartz immersion heater and a 300 W silicone heater tape. Stirring was provided by a 1/8 hp variable speed DC motor and controller. Positive ventilation through a water-cooled condenser was provided. The tanks were used on a four-position leach stand with hydraulic height adjustment at each position.

3.3.3 Leach Procedures

In the normal leaching sequence, concentrate was reacted with 1st stage chlorination solution in the 1st stage; settled 1st stage residue was reacted with fresh leach solution in the 2nd stage; and settled 2nd stage residue was reacted with fresh leach solution in the 3rd stage. To start the process, concentrate must be reacted with fresh solution in a manner analogous to the second stage leach. The procedures shown below are typical; some details differ in specific tests as previously outlined.

3.3.3.1 First Stage Leach

The solution from 1st stage chlorination was heated and any water lost to evaporation was made up. When the solution reached 105°C, 2192 g of New Brunswick concentrate was added. The stirring rate was set at 150 rpm and leaching was done for 30 min at 106-108°C. An additional 244 g of concentrate then was added (2436 g total) and reacted for an additional 15 min. The leach slurry was settled for 15 min and then the supernatent was siphoned off and filtered. The remaining solids were transferred to a 3 l beaker where they were settled again for 15 min and again the supernatent was siphoned off and filtered.

In the preliminary stages of the testwork all of the concentrate was leached for 180 min.

3.3.3.2 Second Stage Leach

The second stage leach was done with 15 litres of fresh leach solution made up as follows:

i) 11.72 kg of water and 3.63 kg of $FeCl_2.H_2O$ were added and the solution was heated under gentle agitation.

ii) at 75°C 2.63 kg NaCl, 0.241 kg $PbCl_2$ and 0.125 kg of $ZnCl_2$ were added.

iii) at 100°C 0.546 l of conc. HCl was added.

The 1st stage settled solids were preheated to 100°C and added when the leach solution reached 105°C. Leaching was done for 90 min at 106 -108°C and a settled slurry was produced as in the 1st stage.

In the preliminary stages of the testwork the second stage leach duration was 270 min.

3.3.3.3 Third Stage Leach

3 l of fresh leach solution was made up as for the second stage and the leach and settling were carried out in an analogous manner. The leach duration was varied from 180 to 300 min. This leach was carried out in a 5 l glass roundbottomed flask at 106 -108°C.

The third stage residue was filtered on a 18.5 cm Buchner filter flask using Barday S4058 filter cloth. The cake was washed twice with 500 ml of boiling 1 M NaCl solution and once with 500 ml of boiling water. The solids were then repulped with 500 ml of boiling water and filtered.

3.3.4 Leaching Results

3.3.4.1 Observations

In the first stage there was a considerable amount of foam formed as the concentrate was added to the lixiviant. As a result the addition had to be made over 5 minutes with extra agitation to avoid boil over. The same problem occured to a lesser degree in the second stage as the settled solids were added. The third stage did not demonstrate this trait.

The concentrate was known to contain calcite and dolomite which combined with the natural floatability of the elemental sulphur present partially explains this phenomenon. However, the second stage leach also foams. Local boiling was another possibility as the solids are added to very hot solutions. Temperature rise measurements were not possible due to the slow addition rate of concentrate and the cooling due to air being drawn across the liquid surface by the ventilation system.

For the pilot plant the leach tanks must be provided with sufficient freeboard to accomodate this foaming. If the foaming problem persists during pilot plant operation even when the recycle liquor has a sufficiently low temperature to prevent boiling, then a commercial plant would also require allowance for foam in the tanks.

3.3.4.2 Metal Extractions

Tables 3.8, 3.9 and 3.10 present the solids assays and extractions based on the solids for Zn, Pb, Cu, and Ag in the first, second and third stage leaches respectively. The mean solids assays and extractions of each element based on feed to that stage are shown in Table 3.7.

TABLE 3.7
Effect of Leach Time on Residue Assay and % extraction in each stage

Leach Stage	Leach Time (min)	Final Solids Zn (%)	Pb (%)	Cu (%)	Ag (ppm)	Extraction Zn (%)	Pb (%)	Cu (%)	Ag (%)
1st Stage	180	18.1	0.13	0.71	142	56	98.9	38	55
	75	18.6	0.10	0.70	156	60	99.3	40	57
	45	18.4	0.18	0.68	147	62	98.8	49	61
2nd Stage	270	1.35	0.11	0.16	49.9	82	16	91	74
	120	1.78	0.08	0.20	46.0	91	25	74	78
	90	3.35	0.12	0.19	67.7	85	48	78	66
	60	6.4	0.09	0.44	82.6	70	50	56	59
3rd Stage	360	0.52	0.07	0.15	28.6	75	0	35	24
	300	0.86	0.12	0.12	36.5	75	0	37	38
	180	2.10	0.11	0.20	45.2	27	0	40	45

The majority of the lead was dissolved in the first stage with the remainder being dissolved in the second stage.

The first stage leach is dominated by lead dissolution resulting in zinc, copper and silver extractions that do not vary with leach time. In the second and third stage leaches the longer leach times result in lower solids assays.

Overall extractions for various tests are presented in Table 3.11.

Table 3.8: 1st Stage Leach Extractions

Test No.	Leach Time (min)	Final Solids				Extraction			
		Zn (%)	Pb (%)	Cu (%)	Ag (ppm)	Zn (%)	Pb (%)	Cu (%)	Ag (%)
*12	300	18.0	0.10	0.71	144	56	99.2	39	54
13	300	18.1	0.15	0.71	139	55	98.6	37	55
*15	75	7.4	0.09	0.38	175	84	99.5	30	49
*16	75	18.3	0.09	0.90	172	60	99.5	29	50
17	75	16.9	0.08	0.71	164	67	99.6	50	58
*18	75	19.4	0.13	0.86	175	58	99.1	32	50
19	75	19.8	0.09	0.64	142	54	99.5	48	63
*20	75	18.7	0.09	0.74	138	59	99.1	42	60
21	75	18.9	0.12	0.66	128	60	99.1	50	69
*22	45	17.6	0.17	0.82	168	62	98.6	36	52
23	45		0.12	0.75	148		99.1	39	56
24	45	16.2	0.26	0.61	122	58	98	44	59
25	45	18.8	0.15	0.69	152	71	99.1	62	71
26	45	19.8	0.21	0.78	145	59	98.8	43	71
27	45	19.3	0.25	0.50	150	59	98.9	62	58
28	45	19.0	0.19	0.64	139	61	98.7	53	63
29	45	17.8	0.11	0.68	145	64	99.6	51	62
30	45	17.7	0.13	0.77	149	64	99.0	45	61
31	45	19.0	0.23	0.60	155	62	98.5	57	60

*leached with prepared lixiviant, balance of tests leached with recycle solution

Table 3.9: 2nd Stage Leach Extractions

Test No.	Leach Time (min)	Final Solids				Extraction			
		Zn (%)	Pb (%)	Cu (%)	Ag (ppm)	Zn (%)	Pb (%)	Cu (%)	Ag (%)
12	270	2.0	0.09	0.23	51.7	93	0	91	75
13	270	0.69	0.13	0.08	48.1	71	31	91	73
15	120	1.00	0.07	0.15	65.4	89	0	57	67
16	120	1.33	0.07	0.20	40.1	94	0	81	80
18	120	3.00	0.09	0.23	44.1	88	50	79	80
20	120	1.82	0.09	0.21	34.2	93	50	80	83
22	60	6.4	0.09	0.44	82.6	70	50	56	59
23	90	3.9	0.08	0.25	71.7	83	50	74	71
24	90	3.4	0.18	0.17	67.2	82	40	76	52
25	90	2.6	0.14	0.18	68.6	90	50	80	66
26	90	3.5	0.11	0.18	66.3	84	50	80	59
27	90	4.0	0.10	0.11	84.3	85	75	78	61
28	90	3.1	0.12	0.17	28.3	88	67	80	85
29	90	3.3	0.09	0.21	63.2	87	0	78	69
30	90	4.6	0.13	0.27	68.2	81	50	75	66

Table 3.10: 3rd Stage Leach Extractions

Test No.	Leach Time (min)	Final Solids Zn (%)	Pb (%)	Cu (%)	Ag (ppm)	Extraction Zn (%)	Pb (%)	Cu (%)	Ag (%)
50 (15)*	180	1.19	0.13	0.10	35.7	0	0	40	50
51 (16)	300	0.54	0.04	0.13	29.9	65	0	38	31
52 (18)	300	0.84	0.04	0.14	35.1	77	0	48	35
53 (20)	360	0.52	0.07	0.15	28.6	75	0	35	24
55 (22)	180	3.0	0.09	0.30	54.7	58	0	40	40
56 (23)	300	1.21	0.12	0.15	42.0				
57 (24)	300	1.18	0.25	0.12	36.5	68	0	0	51
58 (25)	300	0.74	0.23	0.11	34.6	71	0	40	50
59 (26)	300	0.70	0.18	0.11	30.7	78	0	47	54
60 (27)	300	0.56	0.10	0.11	45.9	85	0	25	41
61 (29)	300	0.37	0.08	0.07	34.7	88	0	61	0
62 (30)	300	1.6	0.07	0.16	38.8	64	0	38	42

* Number in bracket shows second stage leach test number which was source of solids for 3rd stage test.

Table 3.11: Overall Extractions

Test No.	Extraction (%) Zn	 Pb	 Cu	 Ag
12	96.9	99.2	94.5	88.5
13	87.0	99.0	94.3	87.9
15 (50)	98.2	99.5	96.2	91.6
16 (51)	99.2	99.5	91.6	93.1
18 (52)	98.8	99.6	92.6	93.5
20 (53)	99.3	99.6	93.0	95.9
22 (55)	95.2	99.3	83.1	87.3
23 (56)				
24 (57)	97.6	98.8	86.6	90.4
25 (58)	99.2	99.6	95.4	95.1
26 (59)	98.6	99.4	94.0	94.5
27 (60)	99.1	99.7	93.7	90.3
29 (61)	99.4	99.6	95.8	88.2
30 (62)	97.5	99.5	91.5	92.3

* Test numbers are for first and second stage leaches. Number in bracket is third stage leach used to complete the test.

3.3.4.3 Rate of Leaching

The rate of leaching of the sulphide minerals present in the concentrate by ferric chloride can be described by rate equations which are consistent with a shrinking core model. In the current testwork the practical features rather than kinetic parameters were investigated.

The most significant rate feature was the very rapid dissolution of galena relative to the other minerals. This is demonstrated in Tables 3.12, 3.13 and 3.14 which present first stage solution assays as a function of time. In each of the tests the lead content of the solution reached its ultimate value at the time of the first sample - 5 min in test D1-31 (Table 3.14). Lead leaching stopped when all the exposed galena was reacted.

Approximately 60% of the zinc leached in the first stage and the majority of the remainder leached in the second stage. Table 3.15 summarizes zinc in solution during second stage leaching.

TABLE 3.12
Solution and Solids Assay for First Stage Leach Test D1-13

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)
0	21.5	12.1	0.50	51.4	234
30	44.8	25.2	1.06	55.2	233
60	46.6	25.3	1.01	54.8	234
90	46.5	25.4	0.99	54.6	234
120	47.1	25.3	1.00	54.6	233
150	47.0	25.3	0.98	53.9	238
180	46.3	25.5	0.99	54.0	231

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
0	25.9	8.8	0.80	14.03
30	19.7	0.11	0.65	20.1
60	19.8	0.16	0.73	19.6
90	18.6	0.09	0.73	18.6
120	19.6	0.10	0.73	19.2
150	19.2	0.09	0.75	20.3
180	18.1	0.15	0.71	19.6

TABLE 3.13
Solution and Solids Assays for First Stage Leach Test D1-21

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)
0	22.1	12.7	0.51	52.8	257
15	48.7	28.8	1.34	56.6	260
30	47.5	27.4	1.31	57.6	255
45	48.1	28.8	1.31	57.6	257
60	49.0	28.8	1.37	57.9	260
75	48.7	28.1	1.24	55.7	252

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
0	25.9	8.8	0.80	14.03
15	19.3	0.14	0.68	23.7
30	18.5	0.12	0.56	24.0
45	18.7	0.11	0.59	24.5
60	18.6	0.12	0.61	23.9
75	18.9	0.12	0.66	24.3

TABLE 3.14
Solution and Solids Assays for First Stage Leach Test D1-31

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)	HCl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)	Fe^{3+} (g/l)
0	17.2	12.5	0.45	52.0			3.6		9.1
5	33.0	27.8	0.75	52.5	048		11.4	26.9	17.2
10	35.8	25.1	0.84	54.3	251		11.7	27.9	12.2
30*	38.3	25.1	1.04	55.2	249		11.9	29.8	1.3
35	40.2	25.8	1.01	54.3	249		12.7	32.4	0.46
40	40.1	25.5	0.97	55.2	246		12.7	32.0	0.16
45	39.8	26.0	0.95	54.8	245		11.7	30.6	0.09

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
5	23.1	0.20	0.77	22.4
10	20.8	0.16	0.77	23.0
30*	17.7	0.15	0.58	23.2
35	19.2	0.15	0.63	22.7
40	19.2	0.27	0.66	23.2
45	19.0	0.18	0.60	23.7

*10% of concentrate added at 30 min.

TABLE 3.15
Solution Zinc Assays During Second Stage Leaching

Time (min)	Test D2-12 Zn (g/l)	Test D2-20 Zn (g/l)	Test D2-30 Zn (g/l)
0	3.7	4.2	3.8
5			11.1
10			13.1
15		16.6	
30	16.9	18.2	15.0
60	18.7	19.8	
90	19.8	20.7	18.5
120	22.7	20.8	
150	20.9		
180	21.8		
210	23.4		
240	22.7		
270	22.5		
Feed Solids Zn (%)	18.0	18.7	17.7

The zinc leaching rates in these three tests were approximately equal.

In the third stage the long residence time compensated for the slow zinc leaching rates. This rate is apparent in the solids assays from Test D2-53 (Table 3.18) which show continued extraction to 360 minutes. In general, the rate of leaching of the sulphide minerals was dependent on the ferric iron concentration; the third stage leach is very sensitive to this factor. The solids density is high and with a small increase in the metal sulphides entering this stage the ferric concentration and the leach rates could drop dramatically.

Copper and silver each leached at relative rate which were slightly lower than that for zinc. This can be seen in the stagewise extractions reported in the previous section. The rates for copper and silver appear to be almost equal.

3.3.4.4 The Duration of Leach Stages

At the start of the testwork a first stage leach time of 180 min and a second stage leach time of 270 min was used. Solution and solids assays from Tests D1-13 and D2-12 are shown as examples in Tables 3.12 and 3.16. It should be noted that the solids assays in Table 3.12 did not change significantly after 30 min indicating the leach time was too long. Also, in Table 3.16 the rate of change in solids assay after 120 min was slow indicating an inefficient use of leaching time.

The first and second stage leach times were shortened and a longer third stage leach was added. Solution and solids assays from Test D1-21, D2-20 and D2-53 are shown as examples in Tables 3.13, 3.17, 3.18. At 75 min the leach time for Test D1-21 was still too long and was shortened in later tests. Table 3.14 shows solution assays for Test D1-31 with a 45 min duration. At 30 min in Test D1-31 10% of the concentrate was added to the leach so that the added unleached sulphide would rapidly reduce the remaining ferric iron concentration. This effect was seen in the ferric iron analysis which reaches 0.09 g/l after 45 min.

The effect of a long third stage residence time can be seen in the results of both Test D2-53 and D2-62 in Tables 3.18 and 3.19 which show continuing zinc dissolution. It appears that even longer residence time could produce higher zinc and silver extractions.

TABLE 3.16
Solution and Solids Assays for Second Stage Leach Test D2-12

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)
0	3.7	10.2	0.03	49.8	208
30	16.9	11.2	0.26	48.9	211
60	18.7	11.4	0.33	49.1	211
90	19.8	11.8	0.38	48.8	215
120	22.7	13.2	0.46	48.8	235
150	20.9	11.7	0.44	48.0	220
180	21.8	11.7	0.48	48.2	215
210	23.4	12.2	0.49	46.6	217
240	22.7	12.1	0.50	47.1	214
270	22.5	11.8	0.50	47.2	217

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
0	18.0	0.10	0.71	21.3
30	7.6	0.11	0.52	28.1
60	6.3	0.09	0.44	24.6
90	4.9	0.08	0.37	25.1
120	4.0	0.09	0.32	24.6
150	3.2	0.08	0.30	25.5
180	3.1	0.09	0.29	25.4
210	2.5	0.08	0.27	25.6
240	2.3	0.09	0.26	25.5
270	2.0	0.09	0.23	27.0

TABLE 3.17
Solution and Solids Assays for Second Stage Leach Test D2-20

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)
0	4.2	11.6	0.03	49.4	226
15	16.6	12.6	0.24	46.6	216
30	18.2	12.4	0.29	46.9	219
60	19.8	13.0	0.37	46.4	226
90	20.7	12.8	0.41	47.3	226
120	20.8	12.3	0.43	47.1	219

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
0	18.7	0.09	0.74	23.9
15	6.6	0.09	0.51	27.8
30	6.1	0.08	0.45	28.7
60	4.8	0.08	0.34	28.0
90	3.3	0.08	0.26	28.7
120	1.8	0.09	0.21	28.7

TABLE 3.18
Solution and Solids Assays for Second Stage Leach Test D2-53 (Solids from D2-20)

Solution Assays

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)
0	0	0.2	0.02	49.1	210
30	7.6	3.8	0.19	51.3	220
60	8.1	3.4	0.20	52.4	217
120	8.5	3.3	0.25	52.5	217
180	8.8	3.4	0.25	50.8	217
240	9.3	3.5	0.30	52.2	217
300	9.3	3.3	0.28	51.9	210
*360					

Solids Assays

Time (min)	Zn (%)	Pb (%)	Cu (%)	Fe (%)
0	1.8	0.09	0.21	28.7
30	1.46	0.07	0.14	29.0
60	1.24	0.06	0.13	28.3
120	1.03	0.05	0.12	28.3
180	0.89	0.06	0.12	28.0
240	0.74	0.05	0.11	28.0
300	0.62	0.05	0.10	28.0
360	0.52	0.07	0.15	29.1

* Assay not reliable

TABLE 3.19
Solution Assays from Test D2-62

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)	HCl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)	Fe^{3+} (g/l)
0	4.0	11.8	0.03	47.5	221	0.8	0.31	0.78	
60	14.0	12.3	0.33	52.5	234	10.8	4.72	9.44	15.6
120	15.2	11.8	0.38	50.1	223	11.7	5.03	10.88	7.9
180	16.4	11.8	0.43	51.1		12.1	5.37	11.68	4.4
240	16.9	11.7	0.43	50.5		11.9	5.44	11.72	1.6
300	17.5	11.6	0.44	50.4	222	11.1	5.48	12.40	0.3

3.3.4.5 The Effect of Concentrate Regrinding

Batches of concentrate were reground for 10 and 20 min at 65% solids to determine the effect of a particle size reduction on leaching rates and extraction. The material was quite friable and the two regrind times produced virtually the same size distribution: 98.3 and 98.9% -400 mesh respectively. For the basis of comparison, tests using 20 min regrind material and as received concentrate will be used.

TABLE 3.20
Effect of Concentrate Regrinding on Residue Assays

	As Received					20 min Regrind				
	Test No.	Zn (%)	Pb (%)	Cu (%)	Ag (%)	Test No.	Zn (%)	Pb (%)	Cu (%)	Ag (ppm)
1st Stage	D1-21	18.9	0.12	0.66	128	D1-17	16.9	0.08	0.71	164
2nd Stage	D2-20	1.82	0.09	0.21	34.2	D2-16	1.33	0.07	0.20	40.1
3rd Stage	D2-53	0.52	0.07	0.15	28.6	D2-51	0.54	0.04	0.13	29.9

No overall trends were observed. The 3rd stage residues produced were very similar. First and second stage zinc extraction may have been enhanced by the regrind.

The only definite effect observed was the decrease in solution sulphate in Test D1-17 versus D1-21. In Test D1-17 (with regrinding) the sulphate rose from 2.92 to 8.51 g/l; in Test D1-21 (without regrinding) 2.64 to 12.2 g/l. This was undoubtedly due to washing of the concentrate in the regrind process.

3.3.4.6 The Effect of a Na_2S Wash of the Concentrate

In a study of the reaction kinetics of the ferric chloride leaching of sphalerite by Jin, Warren and Henein[1], it was reported that a Na_2S wash increased the dissolution rate of ZnS by a factor of four. It was believed that the Na_2S removed the flotation collector on the particle surfaces. To investigate this factor, two batches of concentrate were each washed with a liter of 20 g/l Na_2S for 15 min. The solids were then filtered and washed.

These solids were used in Test D1-18 and D1-19 which had the following solids assays after leaching:

TABLE 3.21
First Stage Leach Residue Assays after Na_2S wash of concentrate

	Solids Assays			
	Zn (%)	Pb (%)	Cu (%)	Ag (ppm)
D1-18	19.4	0.13	0.86	175
D1-19	19.8	0.09	0.64	142
Mean Solids (75 min.)	18.6	0.10	0.70	156

If anything, the zinc extractions may have been less than average in these tests. This may be due to the reduction of residual Na_2S in the concentrate by ferric chloride.

3.3.4.7 Sulphate in Solution

Table 3.22 shows the quantity of sulphate produced in each leach test from 2436 grams concentrate. The data was summarized from the leach mass balances included in Appendix B.

TABLE 3.22
Quantity of Sulphate Obtained in Solution in each Leach Stage

Test No.	1st Stage SO_4^{2-} (g)	2nd Stage SO_4^{2-} (g)	3rd Stage SO_4^{2-} (g)
*12	129	33	18
13	120		
*15 (50)	89 a	36	18
*16 (51)	87 a	34	27
17	72 a		
*18 (52)	78 a	39	21
19	93 b		
*20 (53)	134 b	36	23
21	126		
*22 (55)	138		10
23 (56)	119	18	19
24 (57)	43 c	17 e	
25 (58)	108	17 f	17
26 (59)	116	13	17
27 (60)	70 d	11	16
28	92 d	10	
29 (61)	117	35 f	12
30 (62)	127	38 f	12
31	97		

* prepared lixiviant used in the 1st stage.

number in brackets shows the third stage leach Test No.

Notes:

a. Concentrate reground

b. Concentrate washed with Na_2S

c. 299.4 g $BaCl_2$ added to leach

d. Concentrate washed with pH4 solution

e. 1/2 of normal HCl in lixiviant

f. no HCl in lixiviant

The quantity of sulphate (grams) which appeared in solution during each leach stage is summarized in Table 3.23. Results are shown for standard leach conditions with concentrate as received and for concentrate after pretreatment.

With a sulphate sulphur content of 1.52% a 2436 g batch of concentrate contains 111 g SO_4^{2-}. Without any special treatment the average sulphate yield in the first stage was 120 g indicating a small sulphate production during leaching. Washing the concentrate with a pH4 solution and regrinding (effectively performing a wash) both decreased the sulphate solubilized in the leach by about 40 g. The two batches of concentrate washed with Na_2S were treated at the same time; one batch was used immediately, the other batch was left as a wet filter cake overnight. The second test had a significantly higher sulphate yield than the first: 93 g in Test D1-19, 134 g in Test D1-20.

TABLE 3.23
Summary of Sulphate Increase in Solution
for each Leach Stage

		SO_4^{2-} (g) Increase In Solution
1st Stage	- standard leach procedure	120
	- reground concentrate	82
	- Na_2S washed concentrate	114
	- pH4 washed concentrate	81
2nd Stage	- standard leach procedure	26
	- 1/2 normal HCl	17
	- no HCl	30
3rd Stage	- standard leach procedure	18
	- no HCl	15

The addition of 299.4 g $BaCl_2$ to the leach resulted in 43g of sulphate in solution (Test 24) rather than the 120g produced without additions. The barium chloride has therefore quantitatively removed sulphate from solution and would be effective as a means of sulphate control in the process.

The average sulphate yields of the second and third stages were 26 and 18 grams SO_4^{2-} respectively. To determine whether sulphate production was affected by acid concentration, tests were conducted at half the normal HCl concentration and without any HCl. The results of these tests indicate sulphate production to be independent of acid level.

There was a considerable variation in the sulphate production in the second and third stage: 10 to 39 g SO_4^{2-} and 10 to 27 g SO_4^{2-} repectively. No correlation could be found with any other factor for this variation.

The probable cause of the sulphate formation during leaching is the oxidation of the sulphur content of marmatite under conditions of high redox potential (ferric concentration). Tables 3.14, 3.19 and 3.24 show the relationship between zinc, sulphate and ferric concentration during leaching. In the first stage leach (Table 3.14) the sulphate concentration in solution increases dramatically in the first five minutes. As discussed previously, this increase is due largely to the presence of sulphate in the concentrate. During the balance of the first stage leach, very little sulphate formation is seen and very little zinc is leached. During the second stage leach (Tables 3.19 and 3.24) sulphate formation continues throughout the leach period as does zinc extraction. The third stage leach has a long time duration but little marmatite is dissolved and hence little sulphate is produced.

TABLE 3.24
Solution Assays from Test D2-30

Time (min)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Cl (g/l)	HCl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	3.8	11.5	0.03	47.8	224	0	0.31	0.70
5	11.1	12.6	0.21	47.9	224	0	1.77	3.60
10	13.1	12.5	0.24	48.0	223	0	2.31	4.96
30	15.0	12.7	0.30	48.8	225	2.4	2.59	6.68
90	18.5	12.9	0.42	48.7	226	4.3	3.45	9.80

The concentration of sulphide in the starting and final solutions of each stage is summarized in Tables 3.26, 3.27 and 3.28 for the various leach tests. From this data the mean increases of sulphate in solution were determined as shown in Table 3.25. This table shows the increase in concentration as well as the grams of sulphate added as used throughout this discussion. It should be noted that the third stage has a much higher solids to liquid ratio than the other two stages. It therefore shows a greater increase in sulphate concentration than the second stage although the amount of sulphate formed per unit of concentrate is less.

TABLE 3.25
Mean Sulphate Increases in Leach Solutions

Leach Stage	Sulphate Increase in Solution grams/2436 g conc.	g/l
1	120	9.20
2	26	1.95
3	18	5.34

TABLE 3.26
Acid, Sulphate and Silver Concentration in First Stage Leach Solution

Test No.	HCl (g/l) Initial	Final	SO_4^{2-} (g/l) Initial	Final	Ag (ppm) Initial	Final
*12			0.45	9.60	1.32	18.5
13			2.96	12.5	11.8	35.8
*15			0.49	6.21	23.2	22.1
*16			0.54	5.96	0.28	15.4
17			2.92	8.51	12.8	29.2
*18	14.0	6.8	0.44	5.54	0.5	17.0
19	16.0	13.9	2.92	11.36	11.4	37.8
*20			0.44	9.22	<0.4	18.1
21	16.9	11.1	2.64	12.2	8.8	30.9
*22			0.27	9.62	0.4	16.7
23	20.6	12.9	2.97	12.6	11.4	38.6
24	23.6	13.5	0.63	3.98	11.7	36.5
25	13.3	5.84	2.82	11.8	12	30.6
26	9.1	4.6	3.06	12.0	9.6	31.9
27	19.1	14.1	3.23	8.35	9.8	33.2
28	19.5	15.2	2.93	10.1	13.4	38.2
29	23.5	7.96	2.86	12.2	12.2	34.4
30		7.47	3.64	13.1	10.32	31.4
31			3.6	11.7	9.1	30.6

*leached with prepared lixiviant, balance of tests leached with recycle solution

TABLE 3.27
Acid, Sulphate and Silver Concentration in Second Stage Leach Solution

Test No.	HCl (g/l) Initial	Final	SO_4^{2-} (g/l) Initial	Final	Ag (ppm) Initial	Final
12			0.20	2.55	1.36	11.4
13	12.3	13.5	2.01	2.90	5.72	14.0
15			0.58	2.75	2.3	13.2
16	12.9	13.4	0.59	2.81	0.2	12.2
18	13.5	15.7	0.44	2.65	0.4	13.2
20			0.44	2.58	<0.4	8.9
22	12.4	27.6				
23	14.3	16.2	0.27	2.97	0.4	11.0
24	6.2	9.8	1.52	2.88	1.8	9.6
25	3.5	7.6	1.41	3.03	2.8	9.12
26	15.1	15.8	1.74	3.07	1.56	10.9
27	15.7	16.9	1.66	2.79	2.82	12.3
28	14.9	16.2	1.32	2.63	3.7	12.7
29	3.3	9.8	0.52	3.39	0	9.5
30	0	4.3	0.31	3.45	0.70	9.80

TABLE 3.28
Acid, Sulphate and Silver Concentration in Third Stage Leach Solution

Test No.	HCl (g/l)		SO_4^{2-} (g/l)		Ag (ppm)	
	Initial	Final	Initial	Final	Initial	Final
50 (15)*			0.46	5.78		
51 (16)	12.5	27.8	0.46	7.2	0.3	10.8
52 (18)			0.44	6.36	<0.4	14.4
53 (20)	15.7	23.9	0.48	7.83	<0.4	8.6
55 (22)	12.8	12.2	0.75	4.30		9.0
56 (23)	14.2	23.3	0.69	5.76	0	14.0
57 (24)	12.8	20.9	0.46	5.05	<0.08	13.5
58 (25)	13.0	20.4	0.54	5.86	<0.08	9.6
59 (26)	14.6	25.0	0.57	5.41		13.7
60 (27)	13.8	22.0		4.92		17.9
61 (29)	14.0	16.0	0.36	5.05	0	17.5
62 (30)	0.8	11.1	0.31	5.48	0.78	12.40

* Numbers in brackets show second stage leach which supplied solids for third stage.

3.3.4.8 Iron Extractions

The iron present in the marmatite and chalcopyrite was extracted during leaching. Table 3.29 shows the iron concentrations in solution at the start and end of each leach test and the iron extractions on a solids basis. It is clear that on average the iron concentration increased during each of the three stages as summarized in Table 3.30.

TABLE 3.30
Mean Increase in Iron Concentration for each Leach Stage

Leach Stage	Mean Increase in Fe (g/l) during leach
1st Stage	3.5
2nd Stage	0.6
3rd Stage	3.6

Given that the starting 3rd stage volume is 20% of that for the 1st and 2nd stages, the total iron increase in the leach circuit was in the order of 5 g/l.

TABLE 3.29
Iron Concentration at Start and End of each Leach Stage and Ion Extraction from Solids

Test No.	1st Stage St* (g/l)	1st Stage End (g/l)	1st Stage Ex (%)	2nd Stage St (g/l)	2nd Stage End (g/l)	2nd Stage Ex (%)	3rd Stage St (g/l)	3rd Stage End (g/l)	3rd Stage Ex (%)	Extract (%)
12	48.2	49.1	13	49.8	47.2	10				22
13	51.4	54.0	19	50.2	51.7	5				23
15 (50)	50.7	51.6	11	49.5	49.8	0	48.9	47.1	15	24
16 (51)	48.7	50.6	13	48.0	48.7	-10	48.9	54.6	8	12
17	51.7	54.3	26							
18 (52)	51.3	53.8	20	50.8	49.9	- 6	46.6	51.9	17	30
19	53.7	63.9	8							
20 (53)	47.1	48.9	13	49.4	47.1	15	49.1	54.6	8	32
21 (54)	52.8	55.7	13	50.8	49.1	-14	50.0	51.8		
22 (55)	50.9	52.0	10	48.1		7	48.0	49.2	10	25
23 (56)	57.9	61.4	3	48.3	50.9	8	50.6	54.9		
24 (57)	55.5	57.5	10	49.5	54.2	5	48.2	54.0	9	22
25 (58)	52.9	58.6		49.9	51.9	10	49.7	52.9	0	
26 (59)	53.8	59.4	10	50.7	53.7	1	47.8	52.1	- 3	8
27 (60)	52.6	57.3	11	54.2	50.4	21	48.9	54.6	-13	21
28	54.9	59.7	14	50.9	53.0	13				
29 (61)	51.4	58.1	19	50.0	52.4	18	50.2	53.2	- 4	31
30 (62)	51.9	58.6	19	47.8	48.7	17	47.5	50.4	- 2	31
31	52.0	54.8	22							

* st = start

ex = extraction

The calculated mineralogy in Section 3.1 shows 2.63% $CuFeS_2$ 45.00% $(Zn_{0.95}, Fe_{0.05})S$. This is a marmatite iron content of 1.51%. Leaching 2436 g of concentrate with 15 l of solution should add 3.9 g/l of iron to solution.

The iron extractions in Table 3.29 show erratic variations. It should be noted that these extractions are based on the difference in iron concentration between starting and final leach solutions. Since these differences are very small, typically a few grams per litre, minor variations in analytical results will account for the observed erratic extractions.

3.3.4.9 SEM Examination of the Leach Residue

A portion of the third stage leach residue from D2-53 was mounted, polished and examined by scanning electron microscopy. The residue which was used for this study had the following analysis: 0.52% Zn, 0.07% Pb, 0.15% Cu and 28.6 ppm Ag. After several hours of searching no particles containing Zn, Cu, or Ag were found. Sub-micron inclusions of galena in pyrite were, however, detected.

Another residue from the second stage leach (Test D2-27) was also examined (4.0% Zn, 0.10% Pb, 0.11% Cu and 84.3ppm Ag). A mineral phase was located whose major constituents were copper, silver, antimony and sulphur with a smaller quantity of iron. This phase was most likely tetrahedrite $(Cu, Ag)_{12} S_{b4} S_{13}$. Zinc was found exclusively as free sphalerite particle. No chalcopyrite was found.

3.3.4.10 Screen Analysis of the Residue

A sample of third stage leach residue from Test D2-50 had the following size analysis:

TABLE 3.31
Size Analysis of Final Leach Residue

Fraction (mesh)	Weight (%)
+65	0.11
-65 +100	0.22
-100 +150	1.28
-150 +200	2.97
-200 +325	7.60
-325 +400	1.97
-400	85.85

3.3.4.11 Specific Gravities of the Residues

The specific gravities of the concentrate and of the leach residues from each stage were measured by displacement.

TABLE 3.32
Specific Gravities of Solids in Leach Circuit

Product	s.g.
Concentrate	4.46
1st Stage (D1-21)	3.75
2nd Stage (D2-12)	3.34
3rd Stage (D2-52)	3.14

3.3.4.12 Solution Oxidation

The first stage leach solution from Test D1-31 containing 55 gpl total iron was filtered and gently stirred at 90°C for 5 hours. The Fe^{3+} concentration was initially 0.25 g/l and did not change during this test. This result indicates that fully reduced solutions are not oxidized by exposure to the air, even when they are hot.

3.4 Leach Residue Settling

3.4.1 Settling Apparatus

The settling tests on the first and second stage leach discharge slurries were carried out in 1000 ml graduated mixing cylinders fitted with ground glass tops. These cylinders and their contents were kept hot for the duration of the test by immersing them in a large heated and agitated glass tank.

Only samples taken for settling studies were settled in cylinders. In the bulk of the work the leach solids were settled in the leach tanks.

3.4.2 Settling Procedures

These tests were done by filling the 1 litre graduated mixing cylinder, adding flocculant if required, mixing the cylinder by inversion several times and allowing the cylinder to stand in the hot water tank. Supernatent samples were taken from near the top of the solution column using tipless pipettes. These samples were filtered on tared 1.75 cm glass fiber papers and the supernatent solids were throughly washed using hot NaCl solutions and water. The filter papers were then dried and weighed again to determine the solids weight.

3.4.3 Results and Observations

Without the use of flocculant and with Percol E-10 (anionic) the bulk of the solids dropped rapidly without a settling interface. The residual solids settled more slowly. Using Percol 156 (anionic) a settling interface formed which fell rapidly. The height of this interface was plotted with respect to time.

A layer of solids formed at the top of the settling column as it was being mixed. This layer was quite stable and was left undistrubed as much as possible to avoid distorting the solids density results. For plant operation, a spray should be provided to control froth formation.

Tables 3.33, 3.34 and 3.35 show the change in the supernatant solids density as a function of time for various stages and flocculant loadings.

TABLE 3.33
Settling Results for First Stage Leach Discharge Slurries

Test No.		1	2	3	4
Slurry Source		D1-04	D1-04	D1-04	D1-04
Flocculant		none	Percol E-10	Percol E-10	Percol E-10
E-10 Dosage (ppm)		none	1.0	0.5	0.25
Temp. (°C)		90	90	90	90
		Supernatant Solids Concentration (g/l)			
Time (min)	0	16.91	117.9	123.8	126.3
	5	3.80	1.450	1.53	2.53
	10	1.026	1.104	1.12	1.91
	30	0.612			0.946
	60	0.480	0.236	0.76	0.846
	120	0.396	0.232	0.592	

TABLE 3.34
Settling Results for Second Stage Leach Discharge Slurries

Test No.		6	8	9	10
Slurry Source		D2-05	D2-05	D2-05	D2-05
Flocculant		Percol E-10	Percol E-10	none	Percol E-10
E-10 Dosage (ppm)		1.0	0.25	none	0.5
Temp. (°C)		90	90	90	90
		Supernatant Solids Concentration (g/l)			
Time (min)	0	41.02	16.96	47.36	47.59
	5	0.696	1.350	0.61	0.324
	10	0.890	0.854	0.51	0.312
	30	0.572	0.658	0.33	0.432
	60	0.602	0.494	0.53	0.240

TABLE 3.35
Settling Results for Final Leach Discharge Slurry with no Flocculant and with Percol 156

Test No.		11	12
Slurry Source		D2-55	D2-61
Flocculant		none	Percol 156
Dosage (ppm)		none	1.0
Temp. (°C)		92	91
		Supernatant Solids Concentration (g/l)	
Time (min)		0	98.3
		2	1.088
	5	0.508	0.438
	10	0.598	
	15	1.048	0.604
	30	0.748	0.318
	60	0.634	

A portion of supernatant at 60 min from Test 11, a third stage settling test, was taken and filtered on a Millipore filter. The solids were analysed by energy dispersive X-ray analysis in a scanning electron microscope. The solids were found to be almost exclusively silica.

With no flocculant addition (Test 11) the second stage slurry thickened to 39.7% solids. With the addition of 1.0 ppm Percol 156 (Test 12) the ultimate density was 34.1% solids.

Without flocculant the residual solids of the 1st stage leach slurry dropped out quickly reaching 0.612 g/l in 30 min. Adding 1 mg/l of Percol E-10 produced a lower solids density at 60 min. The addition of 0.5 and 0.25 mg/l of Percol E-10 were less effective than the higher addition at producing a clear supernatant.

The second and third stage leach slurries also clarified well: 0.334 and 0.748 g/l solids at 30 min respectively. The addition of 0.5 mg/l of Percol E-10 improved the second stage results marginally. Percol 156 added to the third stage residue also improved the results but changed the mode of settling. Table 3.36 shows the height of the settling interface in Test 12 versus time.

TABLE 3.36
Interface Height versus Time for Third Stage Slurry with Percol 156

Time (min)	Interface Height (cm)
0	36.0
1	29.2
2	21.5
3	17.9
4	17.3
5	17.1
10	16.3
15	16.1
30	15.5
40	15.2

3.5 Leach Residue Filtration

3.5.1 Filtration Apparatus

The filtration tests were carried out on a 0.10 ft^2 (92.9 cm^2) test leaf. As most of the slurries filtered easily, the leaf was oriented for pour-on tests with a transparent cylinder fitted around the leaf. Wash solutions were added through a distributor to insure their even application. Various filter cloths were tested.

The test leaf apparatus was only used for filtration studies. In the bulk of the leaching work the filtration was carried out on Buchner filters with Whatman GF/A silica filter paper. This paper is very rugged and withstands the hot reagents used.

3.5.2 Filtration/Washing Procedure

Filtration and washing tests were carried out on the final settled leach solids. There were four phases to the procedure:

i) filtration
ii) 1st wash with hot 1 M NaCl
iii) 2nd wash with hot 1 M NaCl
iv) 3rd wash with hot water

After the final wash the air flow was continued for 60 seconds. The cake was then repulped with 500 ml of boiling water and the solids were filtered and dried at 60°C.

3.5.3 Filtering Results and Observations

The most significant feature of the solids filtering and washing was the high filtration rate. Even in tests with very thick cakes ($\sim$5 cm), liquids passed through with very little resistance. After the liquid cleared, the resultant cakes did not crack resulting in effective washing.

The filtering times were very short typically 1 to 2 seconds for 125 ml of slurry, 3 to 5 seconds for 250 ml and 4.5 seconds for 500 ml. Washing times depended marginally on the wash volume and the cake thickness and again the rates were very high.

Tables 3.37, 3.38 and 3.39 show the conditions used and results achieved during filtration tests. All tests were performed on leach slurries which had been settled. The solids feed in Table 3.37 represents the kilograms of solids per m^2 of filter.

TABLE 3.37
Filter Loading, Solids Concentration and Cake Thickness in Filtration Tests

Test No.	Slurry Feed (kg/m^2)	Solids Feed (kg/m^2)	Fabric	Feed % Solids	Cake % Solids	Cake Thickness (cm)
5	40.6	13.6	F4117	33	68	1.59
6	33.0	13.3	F4117	40	70	1.66
7	19.0	6.3	F4117	34	69	0.58
8	20.6	6.6	F4117	33	60	0.76
9	38.7	12.3	F4117	44	60	1.50
10	17.5	3.9	S4058	30	60	0.55
11	16.8	3.6	S4058	22	67	0.59
12	40.3	12.8	S4058	32	69	1.75
13	38.6	12.3	S4058	32	68	1.72
14	19.4	6.1	S4058	31	73	0.63
15	22.0	7.0	S4058	32	72	0.72
16	37.7	9.8	4511	26	62	1.30
17	37.8	12.1	4511	30	63	1.50
18	18.7	5.8	4511	30	63	0.85
19	20.5	6.3	4511	30	62	0.87
20	78.3	33.3	S4058	42	74	3.50
21	79.5	24.6	S4058	31	61	3.00

TABLE 3.38
Wash Volumes and Filter Times for Filtration

Test No.	Volume (ml)					Filter Time (sec)			
	Feed	1st W*	2nd W*	3rd W*	Repulp*	Feed	1st W	2nd W	3rd W
5	250	125	125	125		4	3	3	4
6	250	60	60	60		4	1.5	2	4
7	125	125	125	125		2.5	3	2.5	5
8	125	60	60	60		1.5	1.5	1.5	1.5
9	250	125	125	125		5	3.5	3.5	8.5
10	125	125	125	125		2	2.5	2.5	6
11	125	60	60	60		2.6	1.6	1	4
12	250	125	125	125	500	3.5	4	3	3
13	250	60	60	60	500	3	3	1.5	2
14	125	125	125	125	500	1.5	3	2.5	3
15	125	60	60	60	500	2	1.5	2	1.5
16	250	125	125	125	500	3	3	4.5	3.5
17	250	60	60	60	500	3	1.5	1.5	1.5
18	125	125	125	125	500	1	2.5	2.5	2
19	125	60	60	60	500	2	2	2	2
20	500	250	250[a]	250	500	4.5	7+30	9+30	7+30
21	500	250[b]	250[b]	250	500	4.5	9+30	55+30	6.5+30

Notes:

* 1st and 2nd wash with 1 M NaCl
3rd wash and repulp with water

a. washed with 2 M NaCl

b. washed with water

TABLE 3.39
Filtrate and Wash Stage Filtrate Analyses

Solution Assays (g/l)

Test	Filtrate		1st Wash		2nd Wash		3rd Wash		Repulp	
No.	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn	Fe	Zn
5	41.0	17.0	N.A.	N.A.	5.50	2.90	0.30	0.15		
6	60.0	23.8	N.A.	N.A.	38.0	14.4	5.50	3.05		
7	45.0	16.9	21.0	7.8	1.80	0.70	1.25	0.08		
8	59.0	21.4	46.0	16.8	13.5	6.2	1.90	0.80		
9	43.0	18.6	35.0	15.1	3.05	1.29	0.25	0.14		
10		11.5	13.0	5.4	0.75	0.36	0.10	0.52		
11		11.3	15.0	6.1	4.25	1.80	0.35	0.21		
12	47.0	13.6	37.5	10.3	4.80	3.78	0.88	0.22	0.47	0.13
13	38.5	11.1	28.0	8.05	4.68	1.50	2.13	0.67	0.73	0.21
14	40.0	11.2	21.0	6.15	0.99	0.42	0.13	0.04	0.21	0.07
15	40.5	11.9	33.0	9.15	21.0	6.15	1.20	0.65	0.16	0.004
16	35.5	10.1	32.0	8.8	8.0	3.0	0.86	0.17	0.12	0.04
17	41.5	12.1	36.5	10.4	29.0	8.53	4.10	1.25	0.86	0.26
18	50.0	13.6	52.0	14.7	18.5	5.13	0.95	0.34	0.05	0.02
19	61.0	17.2	62.0	17.3	36.8	11.5	7.5	2.25	0.54	0.16
20	53.7	17.7	55.1	17.9	65.3	24.4	3.5	1.4		0.6
21	53.9	17.9	25.0	8.6	1.47	0.45	0.14	0.05	1.3	0.40

N.A. - reliable values not available.

3.5.4 The Effect of Filter Cloth

Three different filter cloths were tested as detailed in Table 3.40. All the cloths were produced by Barday Western.

TABLE 3.40
Properties of Filter Cloths Used For Study

Cloth	Material	Construction	Weight (oz/sq yd)	Permeability (cfm)
F4117	Polypropylene	2 x 2T	9.	45-60
S4058	Polypropylene	2 x 1B	9.2	1-2
4511	Polypropylene	Finish HSGL	16	25-30

The filtering and washing times for analogous tests did not show any dependence on filter cloth type. For example, Test 5, 9 and 16 all had 250 ml of slurry with 125 ml washes.

All three cloths initially let solids through but this stopped after several tests. The long term stability of these cloth types at the operating temperatures to be encountered has not been established.

3.5.5 Wash Effectiveness

Table 3.41 shows the distribution of zinc removed from the leach slurry through the filtration and washing procedure. The iron removal is not shown but was virtually identical.

TABLE 3.41
Zinc Removal During Filtering and Washing of Leach Residue

Test No.	Slurry Vol (ml)	Wash Vol (ml)	% Zn Removed Fil.	1st W	2nd W	3rd W	Repulp
15	125	60	41	32	26	1	0
19	125	60	26	43	23	5	3
14	125	125	41	53	3	0	3
18	125	125	6	70	23	1	0
13	250	60	60	27	5	2	6
17	250	60	44	29	18	3	6
12	250	125	40	38	17	3	2
16	250	125	50	34	14	1	1
20	500	250 a.	18	34	43	2	2
21	500	250 b.	55	39	2	0	3

a. 2nd wash with 2M NaCl

b. 1st and 2nd washes with water

The tests with the wash filtrate ratios of 1:1 and 0.5:1 removed more zinc than the tests with a 0.25:1 ratio. However, there was little difference between the tests with 1:1 and 0.5:1 ratios.

3.6 Chlorination Testwork

3.6.1 Chlorination Apparatus

Most of the chlorination work was carried out in a glass column 110 cm long x 5.5 cm in diameter packed to a depth of 100 cm with 1 x 1 cm glass cylinders. The column was wrapped with two 300 W heating tapes controlled by variable transformers and insulated with aluminum foil. Chlorine was fed to the bottom of the column via several shut-off and control valves and a rotameter-type flow meter. The gas system was designed to be purged with air. Solution was pumped to the top of the column from a heated, agitated tank by a variable speed Ministaltic pump. The solution was collected at the bottom of the column in a tank. Both the top of the column and the chlorinated solution tank were vented.

Later chlorination tests were carried out in a vented agitated leach tank using a tubular glass frit for chlorine distribution. The chlorine supply used was as above.

3.6.2 Chlorination Procedure

The solutions produced in the 2nd stage leach were chlorinated prior to their use in the 1st stage leach. Each solution was heated to 95°C under agitation to dissolve the $PbCl_2$ present. This solution was then pumped into the chlorination column at 100 or 125 ml/min. Chlorine was admitted to the bottom of the column through shut off and control valves and a rotameter. The tests in which a stirred tank was used were done by heating the solution to dissolve $PbCl_2$ and then admitting chlorine through a tubular frit into the stirred vessel.

The rotameter used was characterized using air and calibrated at two points with Cl_2 by collecting the gas in 20% NaOH and titrating the resultant hypochlorite iodiometrically. The two points were at 1100 and 1800 ml/min of Cl_2.

3.6.3 Observations

The counter-current chlorination system worked smoothly for the most part. It could readily be seen that the solution was oxidized almost immediately at the top of the column. Chlorine was carried over into the collection tank. The only problem experienced was the back up of solution into the chlorine feed line where it would crystallize blocking off the gas flow. Water evaporated from the solutions and was made up prior to the 1st stage leach.

The stirred tank chlorination worked very well. Even at high flows no Cl_2 could be detected from the tank until the end of the test even though in some tests the solution depth was only 11 cm.

3.6.4 Column Chlorination Results

Table 3.42 summarizes the flow rates used and the results achieved in the column chlorination tests. The recorded chlorination efficiencies are low considering the ease with which the chlorination reaction proceeds. The low efficiencies are believed to result from chanelling in the column.

TABLE 3.42
Column Chlorination Conditions and Results

Test (D3)	Solution Flow (ml/min)	Cl_2 Flow (ml/min)	Fe^{2+} In (g/l)	Fe^{2+} Out (g/l)	Cl_2 Eff. (%)
10	100	1100	45.4	20.9	49
11	100	1500	39.2	0	57
12	100	1500	38.8	0	52
13	100	1500	42.9	0	57
14	100	1500	44.5	1.6	63
16	100	1500	36.4	0	53
17	125	1800	36.4	2.2	52
18	125	1800	45.3	0	68
19	125	1800	42.1	0.8	62
20	125	1800	48.1	<1	73
21	125	1800	43.2	0	65

3.6.5 Tank Chlorination Results

The most significant of the four tank chlorination tests was D3-25 done with 13.8 l of solution at an apparent Cl_2 flow of 6800 ml/min (Table 3.43). In this test the Cl_2 flow was stopped every 3 min. to allow samples to be taken. This was not done in the previous three tests and their results did not show a definite result.

TABLE 3.43
Tank Chlorination Results

Time (min)	Solution Temp (°C)	Fe^{3+} (g/l)
0	80	12.1
3	81	17.6
6	83	22.4
9	84	27.2
12	84	32.6
15	86	37.8
18	85	43.1
21	86	* 48.3
24	87	
27	87	50.0

* Cl_2 detected

The most significant feature of these results is the consistent interval between subsequent ferric analyses. The mean oxidation rate over the first 21 minutes was 5.17 g/l Fe^{3+} per 3 minutes interval which was equivalent to a Cl_2 flow of 5200 ml/min. The difference between the apparent and calculated flows was due to the difficulties in calibrating the Cl_2 rotameter at such high flows. The final ferric analysis in Table 3.43 represents complete oxidation of iron in solution.

The solution temperature during chlorination increased from 80 to 87° over the course of the test. In previous tests higher temperature rises were reported: from 95 to 109°C in Test D3-22, from 55 to 74°C in Test D3-23 and from 75 to 84°C in Test D3-24. The variation in temperature rise was most likely due to differences in ventilation across the top of the tank during the tests as this was not controlled. The results suggest that the temperature increase during chlorination should be 19°C or higher.

3.7 Cementation Testwork

3.7.1 Cementation Apparatus

The bulk of the cementation tests were carried out in leach tanks. The remainder were carried out in 1000 ml heated, agitated round bottom flasks.

3.7.2 Cementation Procedure

In the cementation tests the 1st stage leach liquor was heated to 100-105°C under agitation and fine lead powder was added in one large dose or as several smaller doses. The full-sized tests were filtered on a 24 cm vacuum filter using silica filter paper.

3.7.3 Cementation Results and Observations

A large portion of the testwork (unreported) was done with lead powder purchased from BDH. This material turned out to be ineffective; it removed less than half the copper and silver from solution. Another sample of powder produced by Fisher Chemical was obtained from CANMET and this powder produced much better results. Comparison of the two powders showed that the BDH lead was more reddish in colour suggesting oxidation to Pb).

When the lead powder was added to solution it initially would form clumps on the bottom. These would break up after a short period, dispersing the lead. After extended stirring the lead solution mixture would become darker suggesting that fine cement had come off the lead.

Of the cementation tests done, Test D4-18, the results of which are shown in Table 3.44, yielded the most useful information. This test was done with 2 litres of solution.

TABLE 3.44
Copper - Silver Cementation Test Results

Time (min)	Pb added (g)	Pb accumulated (g)	Solution Assay Ag (ppm)	Cu (g/l)	Fe^{3+} (g/l)
0	10	10	32.08	0.978	0.298
15		10	0.60	0.27	0.091
30		10	0.68	0.33	<0.04
40	5	15			
45		15	0.84	0.009	<0.04
60		15	0.84	0.024	<0.04

The initial 10 g of added lead was approximately 2 1/2 times the stoichiometric requirement based on the ferric and copper assay. The silver content of the solution dropped rapidly to about 2% of its initial value and seemed to go no lower with added lead. The ferric iron dropped less quickly and remained below our detection limit of 0.04 g/l. The residual copper required the extra portion of lead and then rebounded from the minimum value of 0.009 g/l.

While the cementation reduced the silver content of the solution below the target value of 1 ppm Ag, the copper concentration remained well above the target value of 0.001 g/l. Several test modifications were attempted to determine if lower residual copper concentrations could be achieved.

In Test D4-19 5.0 g of hydrazine hydrochloride was dissolved in 2.0 litres of test solution before the lead was added and the copper levels were monitored. The purpose of this test was to determine whether reducing the solution prior to cementation would result in lower residual copper concentration. The results of this test presented in Table 3.45 show that the high reducing power of the hydrazine did not help to depress the copper concentration.

TABLE 3.45
Cementation Test with Added Hydrazine

Time (min)	Pb added (g)	Pb accumulated (g)	Cu (g/l)
0	10	10	0.933
15		10	0.083
30	5	15	0.109
45		15	0.031

The filtrate from the test shown in Table 3.45 was treated again using a lower stirring rate than previously. It was noted previously that the copper levels rebounded when the cement became detached from the lead, thereby losing its cathodic protection. The results achieved with the lower stirring rate are presented in Table 3.46. With the lower rate, the copper concentration rebounded less than with more intense stirring.

TABLE 3.46
Copper Cementation with Slow Stirring

Time (min)	Pb added (g)	Cu (g/l)
0	5	0.030
15		0.014
30		0.008
45		0.010

In the other cementation tests done there was less success at achieving low copper concentrations. The reason for this may have been higher initial ferric concentrations which appear to be slow to reduce. Low silver concentrations were regularly obtained but none less than 0.5 ppm.

To attempt to get a lower copper concentration potassium antimony tartrate was added to the solution in Test D4-17. It was hoped to form the alloy Cu_3Sb to depress the copper. The equivalent of 1 g/l Sb was added.

TABLE 3.47
Copper - Silver Cementation with Added Antimony

Time (min)	Pb added (g)	Pb accumulated (g)	Solution Assay		
			Ag (ppm)	Cu (g/l)	Fe^{3+} (g/l)
0			32.2	0.818	0.435
15	4	4	27.7	0.839	0.228
30	4	8	15.5	0.827	0.109
45	4	12	6.7	0.646	0.082
60	4	16	0.8	0.034	0.090
75	4	20	0.5	0.005	<0.04

The results shown in Table 3.47 show that all the processes were initially slowed as lead was used to cement out the added antimony which was equivalent to approximately 5 g of lead. However the processes were slow even in the later portion of the test indicating there was still antimony remaining which was coating the surface of lead added later. Antimony and arsenic are both present in the leach solution.

Although the addition of antimony decreased the minimum copper concentration in solution from 8 ppm to 5 ppm, this change is not considered to be significant enough to warrant the resulting increase in antimony in solution. It is possible that the addition of small quantities of antimony part way through the cementation could result in even lower copper residuals than the 5 ppm achieved in Test D4-17. Within the scope of the present test program it was not possible to optimize the antimony addition.

3.8 Lead Chloride Crystallization

3.8.1 Crystallization Apparatus

Two crystallizers were used in the testwork. Bulk crystallizations were carried out in a modified leach tank equipped with a 1/4" x 10 ft. titanium cooling coil through which cold tap water was passed. The other crystallizer was a 1 litre double-walled glass vessel 28 cm deep with a 7.5 cm i.d. This vessel was agitated by a 5.0 cm glass impeller driven by a 1/18 variable speed DC motor. Water from a constant temperature bath was used to control the crystallizer temperature. Solution could be optionally fed through a glass, double-tube heat exchanger into the crystallizer by a Ministalic pump. Solution and crystals could be removed from this vessel using a level control-suction system. This system consisted of a glass tube extending three--quarters of the way down the crystallizer connected to a receiver under vacuum via a solenoid valve. The solenoid was operated by a level controller and a delay timer. The amount of solution removed per cycle was controlled by the delay time.

3.8.2 Crystallization Procedure

In the bulk crystallization tests $PbCl_2$ crystals were produced by cooling batches of leach solution. First the solutions were heated to 90-100°C to dissolve any $PbCl_2$ present. Cooling water was then passed through the titanium cooling coil to achieve the desired cooling rate, typically from 95 to 40°C in 30 min and then from 40 to 15°C in 120 min. A slow stirring rate of 30 rpm was used. At the end of each test the crystals were allowed to settle for 15 min, the supernatent was siphoned off and slurry was transfered to a 3 litre beaker. The settling and siphoning was then repeated. The resultant crystals were filtered, washed once with 5% HCl and twice with water and then repulped with ethanol, filtered and dried.

In the non-continuous tests using the 1 litre crystallizer the bulk solution was heated under agitation to dissolve any $PbCl_2$ present and 1.07 l was transferred to the vessel. Control of the crystallizer temperature was maintained using a temperature bath and tap water. In the continuous tests the bulk solution was transferred to the vessel and the required test conditions were established before the flow of solution was started. The crystals and solution removed from the vessel during the course of the test were not considered, but rather only the final crystals and solution present after 8-10 residence times for the unit had passed.

In both the continuous and non-continuous tests with the small crystallizer the crystals produced were filtered, washed twice with a saturated $PbCl_2$ solution and once with water and then repulped with ethanol, filtered and dried. The screening of $PbCl_2$ crystals was done dry.

3.8.3 Lead Chloride Crystallization Results

Fine $PbCl_2$ crystals formed promptly whenever the solutions were cooled. No tendency to supersaturation was detected with the filtrates remaining free of crystals. The crystals, in general, did not form persistent coatings on the titanium cooling coils nor on the plastic walls of the leach tanks.

The solubility of $PbCl_2$ was primarily a function of the temperature and the chloride activity. In the range of concentration found in the leach solutions the higher the chloride activity the more lead was held in solution. Table 3.48 shows the measured solubilities of lead chloride as the temperature was cooled from 100°C. In each case the temperature was held for 30 min., the crystals allowed to settle and a sample was taken and filtered.

TABLE 3.48
Lead Chloride Solubility Results

	Temp (°C)	Test D5-11 Pb (g/l)	Test D5-29 Pb (g/l)
	80	20.4	
	70	16.7	
	60	14.5	
	50	12.1	15.5
	40	10.2	
	30	8.8	11.0
	25	8.1	
	20		9.6
	15	6.6	8.9
	10	6.2	9.1
Intitial	Pb (g/l)	23.0	32.0
	Zn (g/L)	4	45.1
	Fe (g/l)	57	57.4
	Cl (g/l)	239	273

Test D5-29 shows a higher lead solubility for a given temperature and has a higher chloride concentration. Note that the change in lead concentration per degree of temperature change decreases as the temperature drops. There was very little difference in either set of data between the lead solubilities at 10 and 15°C.

3.8.3.1 Results from the 1 Litre Crystallizer

The 1 l crystallizer could operate in three modes:

i) as a batch unit which was filled with solution and cooled to produce solubility and crystal data;
ii) as an iso-thermal receiver into which solution was pumped;
iii) as a semi-continuous unit held at constant temperature.

The semi-continuous mode was not found to be useful.

Table 3.49 gives size analyses for crystals produced under various conditions:

A. Test D5-12 (1) Solution cooled as quickly as possible from 95-20°C. Crystals filtered and washed.

B. Test D5-12 (2) As A except crystals held at 20°C for 30 min.

C. Test D5-12 (3) As A except crystals held at 20°C for 60 min.

D. Test D5-13 (1) Solution cooled as rapidly as possible (3°C/min).

E. Test D5-13 (2) As D except cooling rate 2°C/min.

F. Test D5-13 (3) As D except cooling rate 1.5°C/min.

G. Test D5-14 (1) Solution pump through heat exchanger cooling to 40°C. Crystallizer filled at 40°C and held for 30 min. Crystals filtered and washed.

H. Test D5-14 (2) As G except crystal slurry cooled to 20°C and held there for 30 min after the crystallizer was filled.

TABLE 3.49
Screen Analysis of Lead Chloride Produced under Various Conditions

Condition	Screen Analysis, Weight %			
	+200	-200 +325	-325 +400	-400
A	2.1	4.8	2.5	90.6
B	3.4	2.3	2.4	63.1
C	10.6	10.8	15.7	63.1
D	8.0	12.9	9.7	69.5
E	2.7	2.9	5.8	88.5
F	9.4	20.6	9.4	60.7
G	3.0	9.7	6.5	80.8
H	2.9	3.9	3.6	89.5

All the tests done produced very fine crystals. There were some minor changes due to the conditions imposed but the results were not consistent. For example slowing the cooling rate should have produced larger crystals but the results of Tests D (3 °C/min), E (2 °C/min) and F (1.5 °C/min) do not reflect this.

It was felt that even at low rpm the agitator in the 1 l vessel was shearing the solution too much to enable large crystals to grow. No semi-continuous tests were carried out as the 1 l vessel did not produce satisfactory results.

3.8.3.2 Results from Leach Tank Crystallization

Given the problems with the fine crystal size in the 1 litre crystallizer and the lack of variation in the results with the changes in cooling rate and time, the focus of the work was shifted to tests done using a cooled leach tank.

In a full scale plant it would be expected that the pregnant solution would be cooled in a counter-current heat exchanger against the barren solution from solvent extraction which has to be heated. It is expected that this heat exchanger would cool the solution to approximately 40°C. The solution would be further cooled to 15 to 20°C in a stirred tank. Tests were done in the leach tank to simulate this cycle - rapidly cooling to 40°C and then slowly cooling to 15°C.

A. Test D5-15 Cooling from 90 to 5°C in 60 min.

B. Test D5-16 Cooling from 100 to 15°C at 20°C/hr.

C. Test D5-17 Solution at 100°C pumped through a heat exchanger cooling it to 40°C. Tank filled at 40°C and then cooled from 40 to 10°C in 1 hour.

D. Test D5-21 Cooling from 90 to 40°C in 1/2 hour and then to 15°C over 2 hours.

E. Test D5-23 As D

TABLE 3.50
Screen Analysis of Lead Chloride Produced in Cooled Leach Tank

Conditions	Screen Analysis %					
	+100	-100 +150	-150 +200	-200 +325	-325 +400	-400
A	0.5	1.2	4.9	18.3	8.1	67.0
B	12.4	13.2	26.7	23.6	5.0	19.0
C	9.4	14.8	30.6	25.8	5.9	13.5
D	24.8	10.1	13.6	18.9	3.0	30.4
E	5.5	14.2	28.4	33.7	2.6	15.6

The effect of cooling rate can be seen in Table 3.50 in the coarser size distribution produced in B over A. Cooling with the heat exchanger and rapid cooling in the tank down to 40°C followed by a slower cooling also produced coarser size distribution.

Although changes in the size distribution were apparent, none of the tests produced crystals that were very large. The results of the present work indicate that the production of significantly coarser crystals may be very difficult. The pilot plant will have the capability to recirculate the $PbCl_2$ crystals to determine whether continued growth of crystals occurs. As was noted in the testwork using the batch crystallizer however, the crystals are very friable and could break down during recirculation. Until the crystallization circuit is operated on a continuous basis it is not realistic to predict the maximum achievable crystal size.

If the production of large crystals was mandatory and could not be achieved on a continuous basis, the use of batch cooling over a long period could be considered.

3.8.3.3 Sulphate Content of the $PbCl_2$

The normal first stage leach solutions had a sulphate concentration in the order of 11 to 12 g/l. In crystallization, lead sulphate is precipitated, contaminating the product. Table 3.51 shows the sulphate concentrations of the crystals produced.

TABLE 3.51
Sulphate Content of Lead Chloride

Test (D5)	Final Temperature (°C)	$\%SO_4^{2-}$
12 (1)	20	0.64
12 (2)	20	0.57
12 (3)	20	0.51
13 (1)	20	0.51
13 (2)	20	0.47
13 (3)	20	0.46
14 (1)	20	0.61
14 (2)	20	0.50
17	10	0.52
19	15	0.01
21	15	0.03
23	15	0.06
29 (A)	15	0.15
29 (B)	15	0.01

In Tests D5-12 to 17 the SO_4^{2-} in the $PbCl_2$ was in the range of 0.46 to 0.64% and then there was a sudden drop to very much lower levels. Test 19 was done with solution produced in Leach Test D1-24 to which $BaCl_2$ had been added. This solution had 3.98 g/l SO_4^{2-}. However the solution used for Tests 21 and 29 had the normal quantities of sulphate. The solution used in Test 23 originated from D1-28 (10.1 g/l SO_4^{2-}) where the concentrate had been washed with pH4 solution. However, these changes in the solution sulphate were not a plausible explanation to account for the lowering of the $PbCl_2$ sulphate content.

Starting at Test 19 all the solutions were products of cementation whereas previously all the solution had been untreated first stage leach solutions. Although there is no obvious relationship between cementation reactions and the resulting sulphate in $PbCl_2$ crystals, there is a very strong indication that some relationship does exist. It is possible that one or more of the elements removed during cementation results in the precipitation of sulphate during crystallization.

To investigate the effect of added Ba and Ca added to the solutions prior to crystallization a series of tests were done where quantities of $BaCl_2$ and $CaCl_2$ were added, the resultant precipitates were filtered off and the solutions were crystallized.

TABLE 3.52
Effect of Sulphate Removal From Solution on Lead Chloride Purity

Test	Reagent Addition		Filtered Solution		$PbCl_2$
(D5)		(g/l)	Pb (g/l)	SO_4^{2-}	% SO_4^{2-}
25	none		29.0	12.9	0.17
27	$CaCl_2$	16	26.0	10.8	20.97
24	$CaCl_2$	20	16.9	8.51	3.41
28	$BaCl_2$	15	21.1	8.43	0.06
26	$BaCl_2$	30	29.9	1.11	0.09

The first step in the tests, the addition of the $CaCl_2$, seems to have removed lead from solution as well as sulphate. A solution temperature of over 95°C was maintained, however the addition of reagents may have forced $PbCl_2$ out of solution.

The two tests done with the addition of $BaCl_2$ produced a lower sulphate content in the $PbCl_2$ crystals than the test without added reagents. However the two tests done with the addition of $CaCl_2$ produced very high sulphate levels. This was undoubtedly due to precipitation from a supersaturated solution of $CaSO_4$ as very little time separated the reagent addition and filtration step from the $PbCl_2$ crystallization.

3.8.3.4 $PbCl_2$ Settling, Filtration and Washing

The $PbCl_2$ crystals are quite dense (s.g 5.85) and all but the finest crystals, settle rapidly. Typically all the crystals produced from 14 l of solution could be readily settled in three stages into volumes as low as 100 ml of slurry. Filtering and washing tests were done on these crystals on the 0.1 ft^2 test leaf.

The crystals that were used for filtration/washing testing were all produced by cooling a solution from 95 to 40°C in 1/2 hour and then to 15°C in 2 hours. Table 3.53 summarizes the results of the tests.

TABLE 3.53
Lead Chloride Filtration and Washing Results

Test No.	Stage	Volume ml. In	Volume ml. Out	Filtrate Zn g/l	Filtrate Pb g/l	Cake Thickness cm.
D5-18	Feed		112	50.6	10.3	
	1st Wash	100	70	0.54	0.05	
	2nd Wash	100	79	0.26	0.04	
	3rd Wash	100	167	0.08	0.02	1.75
D5-23	Feed		325	60.5	8.0	
	1st Wash	100	130	41.5	4.5	
	2nd Wash	100	100	3.5	2.1	
	3rd Wash	100	105	0.4	2.5	2.05
D5-29A	Feed		64	48.1	9.14	
	1st Wash	200	188	30.3	4.46	
	2nd Wash	200	199	2.9	1.29	
	3rd Wash	200	295	0.2	6.14	2.2
D5-29B	Feed		77	48.1	9.14	
	1st Wash	100	95	32.7	6.02	
	2nd Wash	100	113	15.2	1.66	
	3rd Wash	100	184	1.3	3.09	2.2

In each test the 1st wash was done with a 5% HCl solution and the 2nd and 3rd washes were done with water. The solids concentration in the feed to the filter varied from 40 to 59% solids by weight. The $PbCl_2$ crystals filtered and washed quickly, requiring less than 10 seconds for each stage with the thickness of crystals used. A suction drying time of 60 seconds was allowed for each test producing final filter cakes at 90% solids.

The three wash stages resulted in crystals having impurity levels as shown in Table 3.54.

TABLE 3.54
Impurity Content of Washed $PbCl_2$ Crystals

Test No.	$PbCl_2$ Crystals			
	% Zn	% Fe	% Na	% SO_4
D5-23	.006	<.002	0.5	0.06
D5-29A	.08	<.012	0.01	0.15
D5-29B	.002		0.014	0.15

In Test D5-23 0.5% Na remained in the $PbCl_2$. Most likely NaCl was co-crystallized in this test. Large concentrations of Na were found in the wash solutions of some preliminary tests where the feed solutions had undergone extensive evaporation.

To check for NaCl co-crystallization a test was done in which the temperature of a batch of solution was lowered. Samples were taken and filtered, but not washed.

TABLE 3.55
Impurity Content of Unwashed $PbCl_2$ Crystals

Temperature	Solution Assays (g/l)				$PbCl_2$ Assay (%)			
°C	Pb	Zn	Na	Fe	Zn	Na	Fe	SO_4^{2-}
50	15.5	48.0	82	59.5	0.30	0.52	0.364	0.13
30	11.0	49.7	85		0.35	0.60	0.424	0.15
20	9.6	49.6	86		0.43	0.72	0.494	0.37
15	8.9	48.4	83		0.46	0.78	0.522	0.19
10	9.1	48.1	89	59.4	0.37	0.60	0.432	0.21

Based on the relative Na/Zn assays of the $PbCl_2$ crystals and the solution, Na was not concentrated in the crystals. However with an initial solution sulphate concentration of 13.4 g/l, sulphate was definitely concentrated in the crystals.

3.9 Solvent Extraction

3.9.1 Solvent Extraction Apparatus and Procedure

Solvent extraction was carried out in a multistage Hazen-type cascade extractor. The device was originally built up with seven mixer-settler stages: three extraction and four stripping, but was subsequently built up to nine stages: three extraction, one scrub and five stripping. Each mixer was a round-bottomed cylindrical vessel 5.5 cm in diameter with an effective volume of 340 ml. Each settler was a round-bottomed cylinder vessel 5.5 cm in diameter with an effective volume of 640 ml. The mixer overflows to the center of the settler. The organic phase then overflows the settler to a tee at the bottom of the next mixer and the aqueous "overflows" via a raised tee which also acts as a suction break, to a tee at the bottom of the preceeding mixer. The height of the raised tee controls the relative amounts of organic and aqueous in each settler. The various solutions were fed to the system by a reciprocating tubing pump with four independently variable channels. The various effluents overflowed to appropriate containers. The solvent was recycled.

The operation of the solvent extraction circuit utilized counter-current flow of organic and aqueous phases through the extraction, scrub and strip stages.

The solution flow rates typically were 85 ml/min of 25% Solvesso 150: 75% tri-butyl phosphate (TBP) on a volume basis; 35 ml/min of crystallizer effluent; 17 ml/min of 40 g/l Zn, pH1 scrub solution; and 43 ml/min of 15 g/l Zn, pH1 strip solution. The solvent extraction parameters were obtained verbally from CANMET.

The solvent extraction apparatus was never drained throughout the course of the testwork. For each test with a new solution the operation of the circuit was continued for a sufficient time for stable solution concentrations of zinc to be achieved.

The organic was recycled continuously from the final settler following stripping to the final extraction mixer-settler.

As the solvent extraction testwork progressed, the only changes which were made were in the equipment configuration as summarized in Table 3.56. The configuration used in Test No. 15 is shown in Figure 3.1.

TABLE 3.56
Configuration of Solvent Extraction Circuit

Test		Stages		O/A Vol. Ratio		
No.	Ex	Scrub	Strip	Ex	Scrub	Strip
10	3		4	2.5:1		2:1
11	3		4	2.5:1		2:1
12	3*		5	2.5:1		2:1
13	3	1	5	2.5:1	5:1	2:1
14	3	1	5	2.5:1	5:1	2:1
15	3	1	5	2.5:1	5:1	2:1

* extra settler in 3rd stage

3.9.2 Solvent Extraction Results and Observations

The solvent extraction circuit operated very well. A layer of gelatinous crud accumulated at the organic-aqueous interface in the extraction settlers but this crud layer did not appear to interfere with phase separation. A portion of the crud was filtered and analyzed by means of energy dispersive X-ray analysis under a scanning electron microscope. The crud was found to be entirely silica.

Table 3.57 presents the results of solution analysis for Zn, Pb and Fe in the settling stages of several solvent extraction tests after 240 minutes of continuous operation.

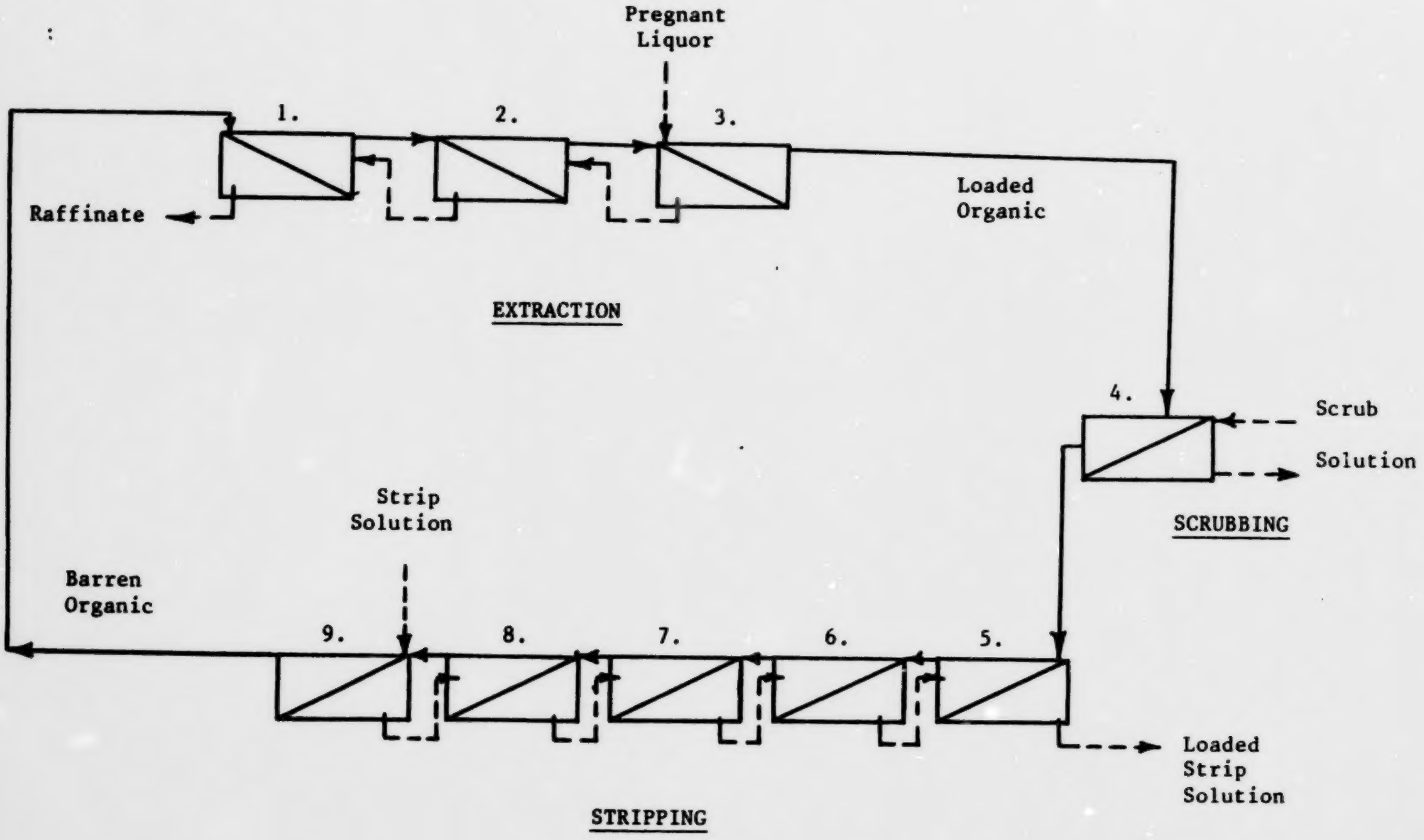
Pregnant
Liquor
1.
2.
3.
Raffinate
Loaded
Organic
EXTRACTION
4.
Scrub
Solution
SCRUBBING
Strip
Solution
Barren
Organic
9.
8.
7.
6.
5.
Loaded
Strip
Solution
STRIPPING

FIGURE 3.1

Solvent Extraction Flowsheet Showing Numbering of Stages

TABLE 3.57
Composition of Solutions in Solvent Extraction Tests

Test D6-11

	Extraction				Stripping				
	1AQ	2AQ	3AQ	3ORG	4AQ	5AQ	6AQ	7AQ	7ORG
Zn (g/l)	17.5	28.0	41.4	25.5	43.5	40.3	32.6	23.7	13.0
Pb (g/l)	7.5		7.6	1.8	0.6			<0.1	1.8
Fe (g/l)	57.7		61.7	7.8	3.5			0.3	3.3

Test D6-12

	Extraction				Stripping					
	1AQ	2AQ	3AQ	3ORG	4AQ	5AQ	6AQ	7AQ	8AQ	8ORG
Zn (g/l)	19.0	30.4	44.4	26.3	44.3	38.6	32.3	25.0	20.7	11.5
Pb (g/l)	10.0		10.0	1.5	0.4				<0.1	
Fe (g/l)	63.7		66.4	6.5	3.8				<0.1	

Test D6-13

	Extraction			Scrub	Stripping		
	1AQ	3AQ	3ORG	4AQ	5AQ	9AQ	9ORG
Zn (g/l)	18.7	42.3	26.3	38.6	39.1	20.0	15.5
Pb (g/l)	7.7	8.2	1.8	4.4	0.7	< 0.1	1.3
Fe (g/l)	57.7	60.8	1.0	25.1	4.0	<0.1	1.8

The raffinate in these tests has a high zinc content (17 to 19 gl/Zn). This results in a high circulating load of zinc in the process. The addition of an extra stripping stage in Tests 12 and 13 compared to Test 11 did not decrease the zinc concentration in the barren organic and therefore also not in the raffinate. These tests were all done using the CANMET guideline that the strip feed solution contains 15 gpl Zn. Consideration should be given to the possibility of using a strip feed solution containing less than 15 gpl Zn and whether this would reduce the zinc concentration throughout the circuit.

Table 3.58 summarizes the composition of the loaded strip solutions (aqueous) from several tests. The decrease in impurity level in these solutions as the testwork proceeded is not related only to the change in circuit configuration. The composition of the feed solution to solvent extraction, in terms of impurity content, was also improving as the test program proceeded. The results indicate that the loaded strip solution will have to be purified prior to electrowinning.

TABLE 3.58
Composition of Loaded Strip Solution

	Solution Assay (g/l)				
Test	**Pb**	**Zn**	**Fe**	**Cu**	**Na**
D6-10	1.01	45.4	10.1	0.90	9.63
D6-11	0.33	46.6	4.15	0.92	3.84
D6-12	0.13	45.4	2.60	0.69	1.96
D6-13	0.17	40.2	1.83	0.74	1.25
D6-14	0.08	49.8	0.75	0.47	0.46
D6-15	0.03	50.9	0.90	0.04	0.43

It was observed that while the feed solution to solvent extraction contained up to 11.3 g/l HCl, the raffinate was free of acid. The acid is apparently extracted from solution along with the zinc.

3.9.3 Strip Solution Purification

The strip solution from D6-14 was first dripped through a 36 cm column, 3.5 cm in diameter fitted with 12-20 mesh activated carbon. The flow rate was 30 ml/min. 1 litre batches were tested by the following procedures.

Test A: Solution was oxidized to a potential greater than +700 MV vs SCE using a few drops of satium hypochlorite solution. ZnO was added to pH 3.5. 2 g of Zn dust was added and stirred for 15 minutes. Solution was filtered.

Test B: As A except the solution was filtered after the ZnO addition.

Test C: As A except ZnO added to pH 2.0.

TABLE 3.59
Results of Alternative Purification Procedures

Test	Fe (ppm)	Pb (ppm)	Cu (ppm)
Feed	656	67	488
A	< 1	8	26
B	< 1	8	64
C	416	24	77

The strip solutions from Tests D6-12, 13 and 15 were treated in an analogous manner to Test A. One batch of D6-15 solution had an additional dose of 2 g/l Zn dust after 15 minutes after which the slurry was stirred for a further 15 minutes (15*).

TABLE 3.60
Purification Test Results

Strip Solution	Fe (ppm)		Pb (ppm)		Cu (ppm)	
	Feed	Product	Feed	Product	Feed	Product
12	2600	< 1	130	14	690	68
13	1830	< 1	170	34	740	147
15	900	< 1	30	6	40	9
15*		< 1		5		6

The results presented in Table 3.59 indicate that a ZnO addition to pH = 2.0 is inadequate for impurity removal while an addition to pH = 3.5 is adequate. The results also indicate that filtration between ZnO and Zn dust addition should not be done.

The results presented in Table 3.60 indicate that impurity levels after purification are strongly dependent on the impurity concentrations in the feed solution to purification. Doubling the Zn dust addition in Test 15* had only a slight effect on the final impurity concentration.

3.9.4 Solution Specific Gravities

The solution densities of the aqueous and organic phases in each settler were measured in Test D6-15. The measurements were made by weighing 25 ml of pipetted solution.

TABLE 3.61
Specific Gravity of Solutions
in Solvent Extraction Circuit

Settler No.*		Organic g/ml	Aqueous g/ml
1	Ex.	0.971	1.257
2	Ex.	0.979	1.282
3	Ex.	0.989	1.304
4	Scrub	0.988	1.096
5	Strip	0.982	1.077
6	Strip	0.976	1.066
7	Strip	0.971	1.053
8	Strip	0.965	1.044
9	Strip	0.961	1.032
Feed Solution			1.319
Raffinate			1.258
Scrub Solution	In		1.018
	Out		1.079
Strip Solution	In		1.060
	Out		1.100

* Settlers are numbered as in Figure 3.1

3.10 Turboaeration

3.10.1 Turboaeration Equipment

The turboaeration was carried out in a double-walled cylindrical glass vessel 28 cm high with an internal diameter of 7.5 cm. The solution was mixed by two pairs of rotors and stators. Each rotor had 6 turbine blades 2.7 cm in diameter with a 0.2 cm clearance relative to the stators. The stirrer was driven by a 1/8 hp variable speed DC motor. Air and oxygen were admitted to the bottom of the vessel through a tubular glass frit via a rotameter. The desired temperature was maintained by pumping water from a constant temperature bath through the vessel's jacket.

3.10.2 Turboaerator Procedure

In the turboaerator tests, solvent extraction raffinate was reacted with air or oxygen. The turboaerator was charged with raffinate which was then heated to reaction temperature. Oxygen was fed in through a rotameter for the test duration. The product slurry was then vaccum filtered and washed with hot water.

3.10.3 Turboaerator Results

3.10.3.1 Observations

The solution in the turboaerator changed colour to the characteristic ferric reddish-brown as soon as the oxygen was admitted. Solids precipitated shortly thereafter. The solids produced did not settle well naturally but filtered very quickly.

3.10.3.2 Rate of Oxidation

In turboaeration ferrous iron is reacted with oxygen.

$$4\ Fe^{2+} + O_2 + 4\ H^+ = 4\ Fe^{3+} + 2\ H_2O$$

The rate of this reaction is controlled by the mass transfer of oxygen at high Fe^{2+} concentrations and by the chemical rate at low Fe^{2+} concentrations.

Under mass transfer control the rate of Fe^{2+} oxidation is linear with the following factors.

i) temperature
ii) oxygen partial pressure
iii) power input (stirrer speed)
iv) gas rate
v) solution composition

Under chemical control the rate of ferrous oxidation has the following form:

$$\text{rate} = K\ a_{H+}\ a_{Cl-}\ [Fe^{2+}]\ P_O\ 2$$

where a_{H+} = activity of the H^+ ion
a_{Cl-} = activity of the Cl^- ion
$[Fe^{2+}]$ = ferrous iron concentration
PO_2 = oxygen partial pressure

At a constant activity of H^+ the log [Fe^{2+}] versus time is linear.

Analysis of the results indicates that the tests done were initially under mass transfer control. Figures 3.2 to 3.5 present the Fe^{2+} concentrations versus time for each test.

TABLE 3.62
Turboaeration Test Conditions and Results

Test (D7)	Temp (°C)	Agitator rpm	O_2 Flow (ml/min)	Slope (g/l Fe/min)	Feed Solution (D6)
2	85	1823	370	-0.250	5
3	85	1304	370	-0.183	5
4	85	1553	370	-0.249	5
5	85	2029	370	-0.248	5
6	80	1833	370	-0.263	5
7	90	1833	370	-0.341	5
8	75	1833	370	-0.219	5
9	85	1833	183	-0.229	5
10	85	1833	370	-0.483	9
11	85	1833	370	-0.511	9
12	85	1833	71	-0.344	9

Tests 2 to 5 showed that there was very little variation in the oxidation rate versus stirrer rpm. above 1553 rpm. The power input at increasing rpm is calculated according to the following equation. Values are summarized in Table 3.63.

$$\text{Power per turbine} = 6.3\ N^3\ D^5\ \text{(ft.lbs)}$$
$$= 8.54\ N^3 D^5\ \text{(joules)}$$

N = rps
D = turbine dia (ft)

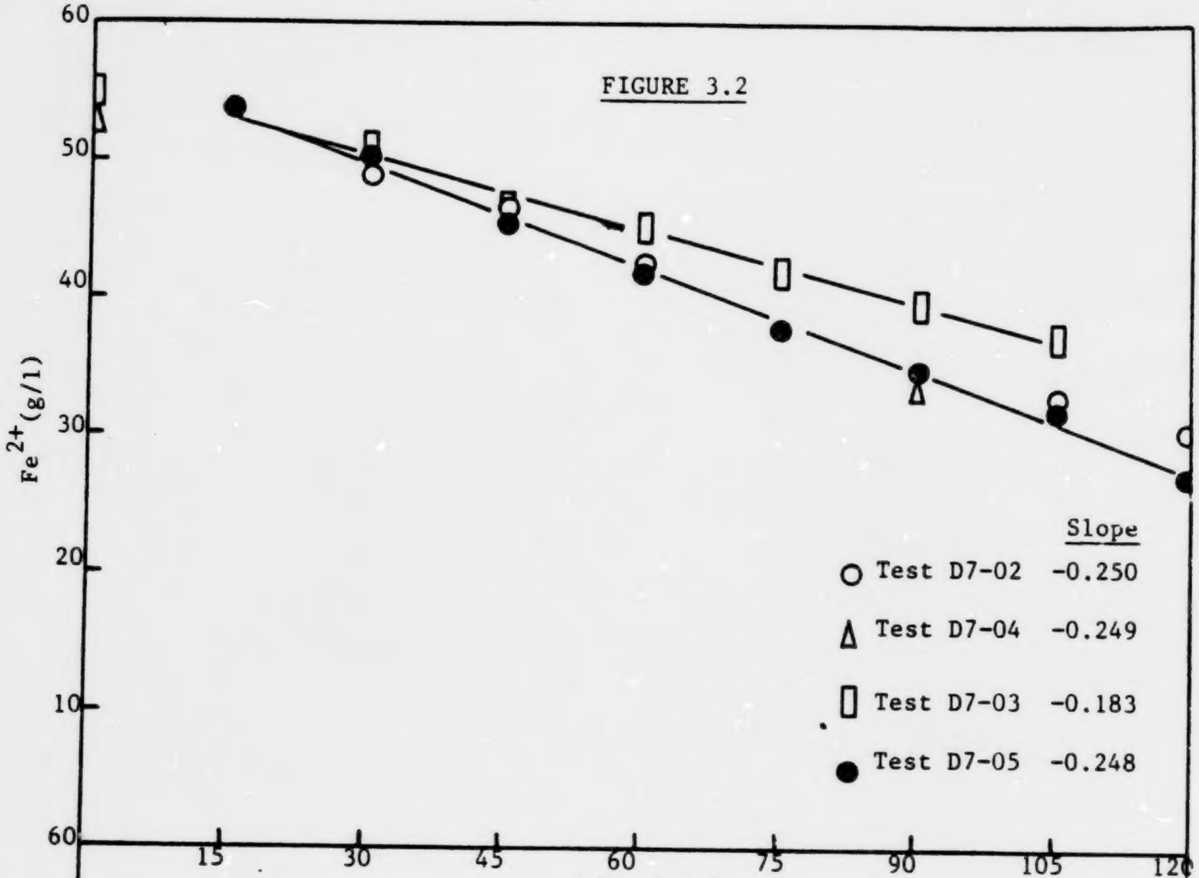

FIGURE 3.2

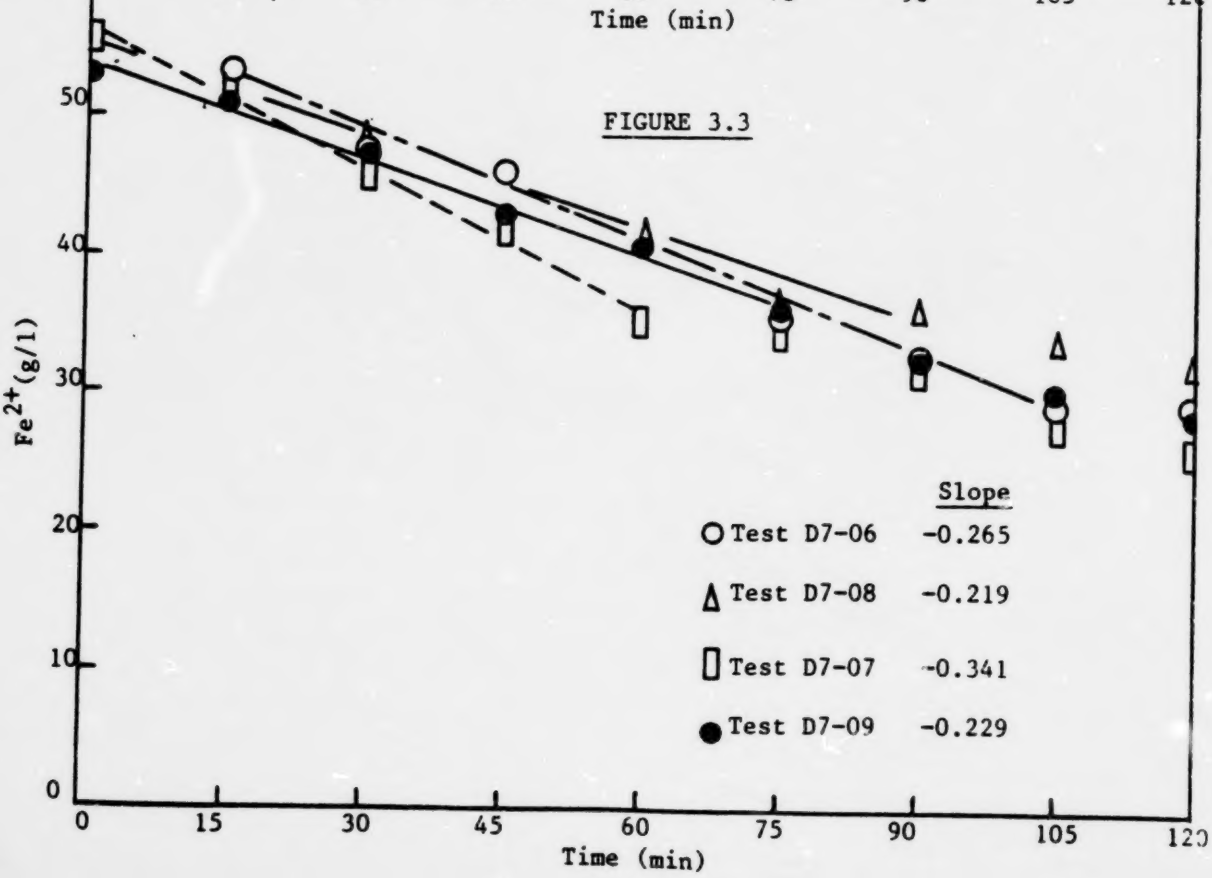

FIGURE 3.3

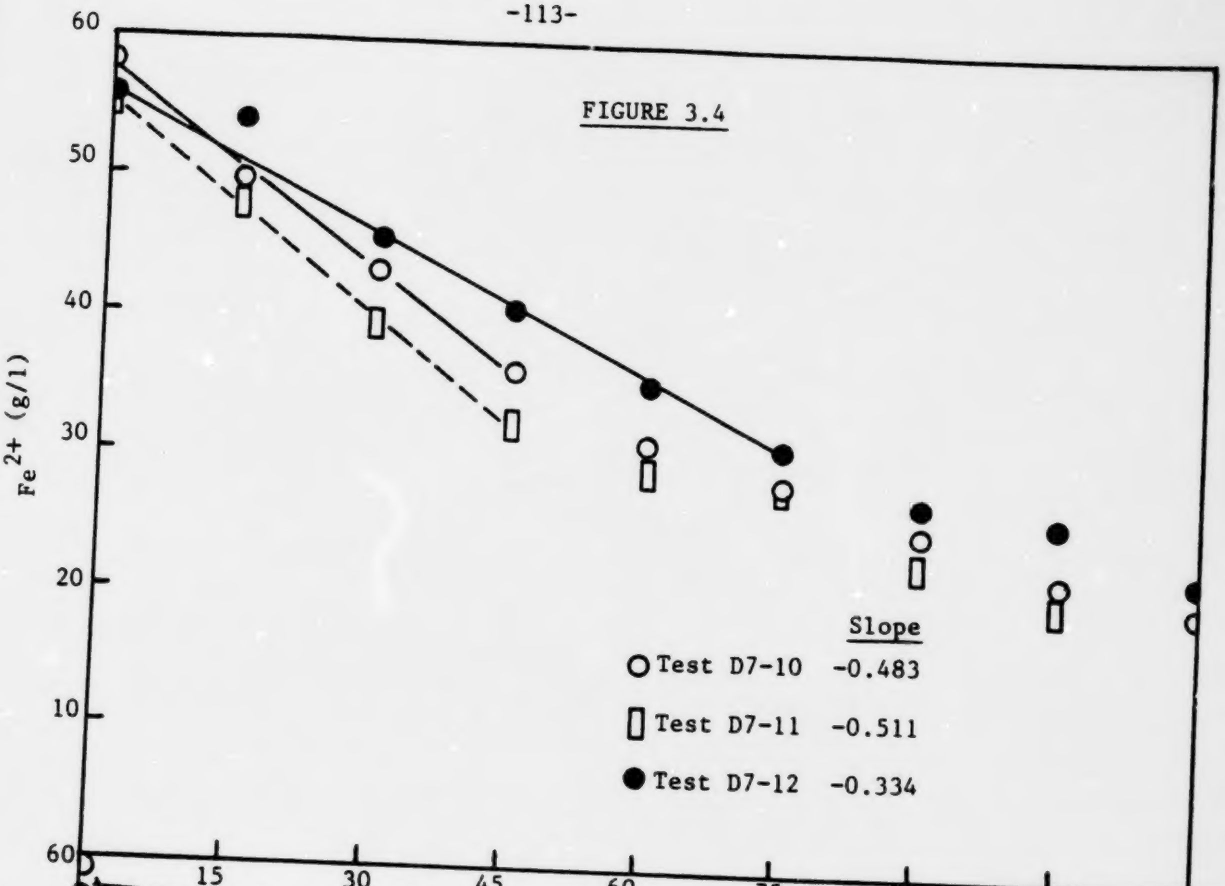

FIGURE 3.4

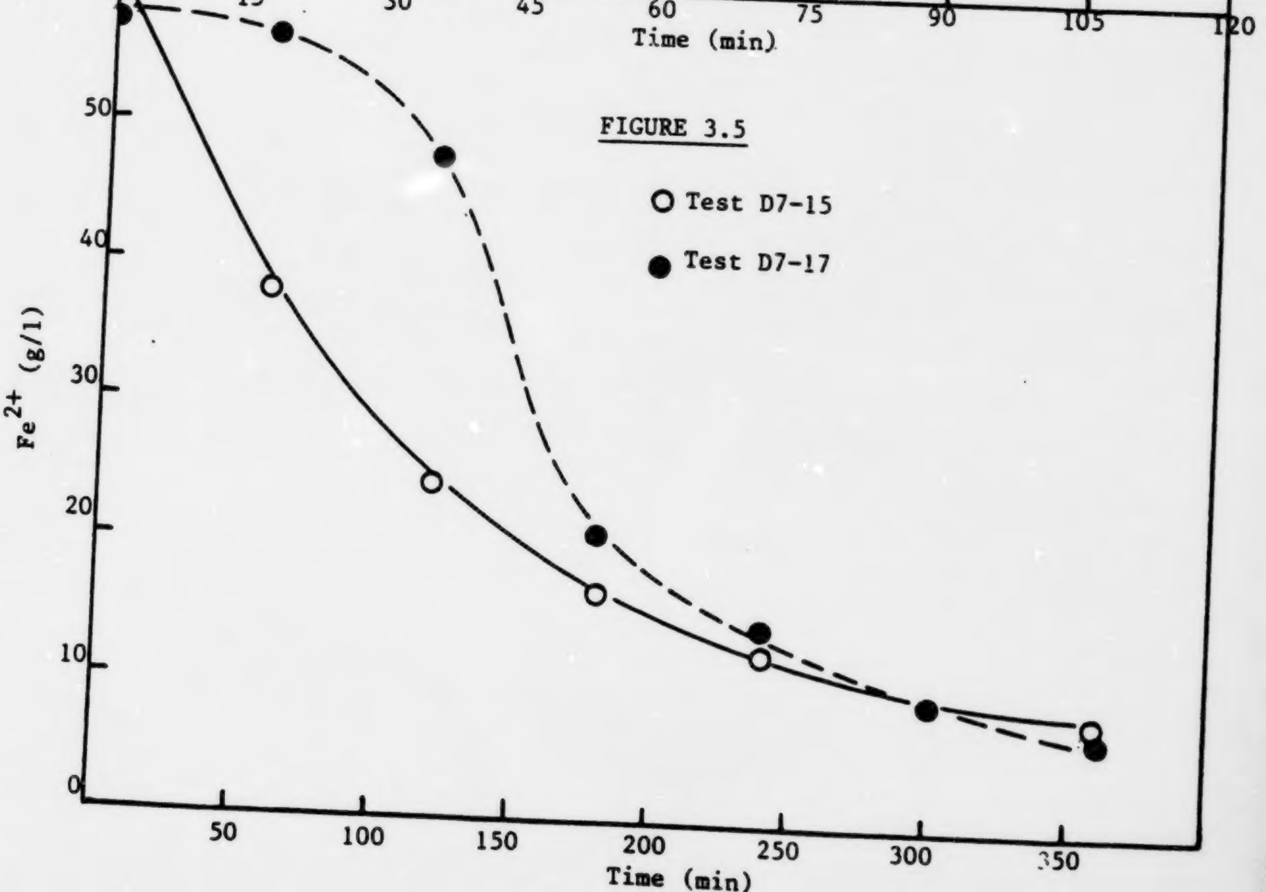

FIGURE 3.5

TABLE 3.63
Relationship Between Turbine RPM and Power Input

rpm	hp/1000 US gal (two turbines)
1304	4.9
1553	8.2
1833	13.5
2029	18.3

Tests 2,6,7 and 8 demonstrated the effect of temperature, with the oxidation rate increasing with rising temperature. Tests 9 to 12 demonstrated the effect of oxygen flow with increased oxidation rate at the higher oxygen flow rate.

Two batches of solution were used in the testwork. Solution from Test D6-05 was used for Tests 2 to 9 and solution from Test D6-09 was used for Tests 10 to 12. The two solutions oxidized at different rates. Tests 2 and 10 are analogous in all other factors and yet the results show that the D6-09 solution oxidized at almost twice the rate of the D6-05 solution. The assays for these two solutions are presented in Table 3.64.

TABLE 3.64
Composition of Solutions used for Turboaeration Tests

Test	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (g/l)
D6-05	5.3	4.5	0.13	63	169	10.1	19.7
D6-09	8.9	12.0	<0.01	72	193	12.2	28.0

Copper is known to be an oxidation catalyst but does not appear to be a factor in this instance. Both solutions had no acid present as acid was removed from solution by solvent extraction.

It is apparent that a chemical control is being exerted on the oxidation rate and that the source of this control is not evident from the analysis for major constituents shown in Table 3.6.4.

3.10.3.3 Iron Precipitation

Once formed, a portion of the ferric iron precipitates as one of various basic iron or basic iron sulphate compounds. Acid is produced as illustrated by the hematite precipitation reaction shown below.

$$2\ Fe^{3+} + 3\ H_2O = Fe_2O_3 + 6\ H^+$$

The course of iron removal is demonstrated by the results of two turboaeration tests, D7-02 and D7-10. These tests were done with different feed solution as described in the previous section.

TABLE 3.65
Iron Precipitation During Turboaeration

Time (min)	Test D7-02, Fe (g/l)		Test D7-10, Fe (g/l)	
	Total Fe	Removed Fe	Total Fe	Removed Fe
0	56.8	0.0	59.9	0.0
15	55.4	1.4	58.0	1.9
30	54.3	2.5	54.8	4.1
45	55.9	0.9	51.9	8.0
60	54.8	2.0	50.0	9.9
75	52.4	4.4	47.5	12.4
90	50.2	6.6	47.0	12.9
105	50.6	6.2	46.5	13.4
120	49.0	7.8	46.2	13.7

In Test D7-02 there was an induction period where the decrease in iron is slow. This is typical for the tests using this same feed solution. In Test D7-10 the iron level drops more quickly than in Test D7-02 as a result of oxidizing more quickly.

Table 3.66 summarizes the iron and sulphate concentration in the solution and in the solids produced and the relative sulphate to iron on a molar basis.

TABLE 3.66
Sulphate and Iron Removal During Turboaeration

Test No.	Time (min)	Solution Assay (g/l) Fe Start	Fe End	SO_4^{2-} Start	SO_4^{2-} End	Solids Fe %	Solids SO_4^{2-} %	SO_4^{2-}/Fe (M/M)
4	120	54.7	47.9	10.6	3.51	29.3	37.2	0.458
5	120	61.4	47.9	9.15	3.20	24.1	33.1	0.423
6	120	55.5	48.2	9.82	3.93	27.8	37.4	0.432
7	120	56.1	48.1	10.0	1.95	30.9	38.0	0.472
8	120	57.4	50.7	8.54	5.79	23.0	40.5	0.330
9	120	54.7	49.0	9.99	2.58	31.5	35.9	0.510
10	120	59.9	46.2	12.2	3.25	18.4	32.8	0.326
11	120	61.8	48.3	12.1	5.19	30.7	33.2	0.538
12	120	62.0	47.5	12.9	2.79	24.1	36.2	0.387

The results in Table 3.66 indicate that the precipitate which is formed during turboaeration is an iron sulphate compound. Table 3.67 presents results for two tests to show the variation in sulphate to iron ratio as precipitation proceeds.

TABLE 3.67
Sulphate to Iron Ratio in Turboaeration Solids

Test No. (D7)	Time (min)	Solids SO_4^{2-} %	Fe %	SO_4^{2-}/Fe (M/M)
15	60	22.8	27.9	0.475
	120	28.1	40.9	0.399
	180	26.9	41.2	0.380
	240	25.5	41.3	0.359
	300	24.5	41.8	0.341
	360	18.3	32.8	0.324
17	60	3.9	18.7	0.121
	120	15.2	28.8	0.307
	180	16.9	29.5	0.333
	240	15.4	27.5	0.326
	300	16.2	28.8	0.327
	360	25.3	42.3	0.348

The results from Test D7-15 indicate that the initial precipitate to form has a higher sulphate to iron ratio than precipitate which forms later. The same observation is not made in Test D7-17.

3.10.3.4 Solids Settling Rate

The turboaerator solids did not settle well without flocculant or with Percol E-10. A more successful test was carried out with Percol 156 as presented in Table 3.68.

Slurry Source	D7-16
Flocculant	Percol 156
Dosage	10 mg/l
Temperature	95°C

TABLE 3.68
Clarification of Turboaerator Discharge

Time (min)	Supernatant Solids Concentration (g/l)
2	6.750
5	2.374
10	3.164
15	2.238
30	2.300
45	2.186
Ultimate Solids Density (%)	27.3

3.11 Trace Analysis of Solids

The following solids were assayed for trace elements by ICP-AES (Induction Coupled Plasma - Atomic Absorption Spectroscopy). All analyses are in ppm.

TABLE 3.69
Trace Analyses of Solids

Element	Conc.	3rd Stage Residue D2-61	Cement Residue D4-15	$PbCl_2$ Crystals D5-25	TA Solids* D7-15
As	2300	3900	52000	<200	500
B	10	20	30	<8	10
Be	<0.8	<0.8	<0.8	<0.8	<0.8
Bi	200	<200	9900	<200	<200
Cd	540	8.3	<4	<4	20
Co	180	280	<8	<8	<8
Cr	8.2	6	<4	<4	195
Cu	8370	660	252000	70	30
Hg	<80	<80	500	<80	<80
Mo	<20	30	<20	<20	<20
Ni	10	<8	430	<8	8
Pb	87300	836	494000	720000	6070
Sb	300	200	28000	<80	200
Se	<80	<80	<80	<80	<80
Th	<40	60	60	<40	<40
U	<200	300	300	<200	<200
V	<4	<4	<4	<4	6
Zn	316000	4450	470	170	6700
Al	330	60	80	7.0	160
Ba	198	318	11	92.3	23
Ca	3800	<80	100	<80	300
Fe	171000	248000	7100	178	301000
K	<400	<400	<400	<400	1600
Li	<80	<80	90	<80	<80
Mg	600	<80	90	<80	80
Mn	447	75	9.2	8.1	113
Na	300	200	500	300	48800
P	<200	<200	<200	<200	<200
Si	<40	<40	<40	<40	<40
Sr	6	<4	<4	<4	5
Ti	<4	6	<4	<4	16
Zr	<8	<8	<8	<8	<8
Ag	219	28	488	<2	10
Au	<8	<8	8	<8	<8
Pd	<40	<40	40	50	<40
Pt	<40	<40	40	50	<40
Rh	<40	<40	<40	<40	<40

* Turboaeration solids

3.12 Trace Analysis of Solution

The following solutions were assayed for trace elements by ICP-AES. All analyses are in ppm.

TABLE 3.70
Trace Analyses of Solutions

Element	1st Stage Product D1-2901	2nd Stage Feed D2-2800	2nd Stage Product D2-2801	Cl_2* Product D3-2201	3rd Stage Feed D2-6100
As	<60	<60	<60	<60	<60
B	<2	<2	<2	<2	<2
Be	<0.2	<0.2	<0.2	<0.2	<0.2
Bi	<40	<40	<40	<40	<40
Cd	90	6.2	38.2	38.6	<1
Co	10	4	6	6	4
Cr	10.8	9.6	9.6	10.0	9.4
Cu	1250	108	612	616	6
Hg	<20	<20	<20	<20	<20
Mo	<6	<6	<6	<6	<6
Ni	12	8	10	10	8
Pb	27000	11100	12800	12900	10700
Sb	<20	<20	<20	<20	<20
Se	<20	<20	<20	<20	<20
Th	<10	<10	<10	<10	<10
U	<60	<60	<60	<60	<60
V	<0.1	<0.1	<0.1	<0.1	<0.1
Zn	58800	7560	25400	25600	3960
Al	100	<100	140	<100	140
Ba	14	<10	22	28	<10
Ca	800	<200	200	200	200
Fe	59400	52400	54200	54200	48400
K	<1000	<1000	<1000	<1000	<1000
Li	<200	<200	<200	<200	<200
Mg	<200	<200	<200	<200	<200
Mn	210	144	160	160	144
Na	71600	72400	71000	70600	67800
P	<400	<400	<400	<400	<400
Si	420	240	<100	<100	<100
Sr	<10	<10	<10	<10	<10
Ti	<10	<10	<10	<10	<10
Zr	<20	<20	<20	<20	<20

* 2nd stage recycle

TABLE 3.71
Trace Analysis of Solutions

Element	3rd Stage Product D2-6150	Cement Product D4-1540	Cement Product D4-1405	SX Feed D6-1400	SX Raffinate D6-1401
As	<160	<60	<60	<60	<60
B	<2	<2	<2	<2	<2
Be	<0.2	<0.2	<0.2	<0.2	<0.2
Bi	<40	<40	<40	<40	<40
Cd	24.8	92.2	94.6	81.0	<69.6
Co	12	10	10	8	8
Cr	9.6	11	11.6	10.6	12
Cu	428	676	494	822	8
Hg	<20	<20	<20	<20	<20
Mo	<6	<6	<6	<6	<6
Ni	8	12	10	<2	8
Pb	11480	27800	31000	5760	5760
Sb	20	<20	<20	<20	<20
Se	<20	<20	<20	<20	<20
Th	<10	<10	<10	<10	<10
U	<60	<60	<60	<60	<60
V	<1	<1	<1	<1	<1
Zn	18600	63800	46400	53800	16400
Al	140	220	160	200	120
Ba	14	14	14	10	<10
Ca	400	800	800	600	600
Fe	53200	62000	62200	53000	54800
K	<1000	<1000	<1000	<1000	<1000
Li	<200	<200	<200	<200	<200
Mg	<200	<200	<200	<200	<200
Mn	160	242	242	184	176
Na	68600	72400	75200	63800	66200
P	<400	<400	<400	<400	<400
Si	<100	100	<100	<100	<100
Sr	<10	<10	<10	<10	<10
Ti	<10	<10	<10	<10	<10
Zr	<20	<20	<20	<20	<20

TABLE 3.72
Trace Analysis of Solutions

Element	SX Strip D6-1423	TA Product D7-1560
As	<60	<60
B	<2	<2
Be	<0.2	<0.2
Bi	<40	<40
Cd	4.4	69.6
Co	<2	8
Cr	<1	8.2
Cu	444	48
Hg	<20	<20
Mo	<6	<6
Ni	2	10
Pb	126	8720
Sb	<20	<20
Se	<20	<20
Th	<10	<10
U	<60	<60
V	<1	<1
Zn	52400	14100
Al	<100	166
Ba	<10	<10
Ca	<200	600
Fe	574	47600
K	<1000	<1000
Li	<200	<200
Mg	<200	<200
Mn	16	226
Na	400	81800
P	<400	<400
Si	400	<100
Sr	<10	<10
Ti	<10	<10
Zr	<20	<20

The leach residue was notable for its relatively high concentrations of As, Co and Ba which was indicative of the presence of refractory minerals of these elements. The Cu/Ag cement proved to be high in As, Sb and Bi as well as the expected elements. The lead chloride crystals were quite pure with no unexpected impurities other than Ba. The turboaerator solids showed significant K, Pb and Na, most likely present as jarosite-type compounds.

The most important information from the solution analyses concerns the accumulation of elements in solution. Comparison of the solution feed to the test program, the 2nd stage leach feed, and turboaerator product solution shows that Cd, Co, Cr, Mn and Ni are accumulating.

References

1. Jin, Zuo-Mei; Warren, G.W; Henein H.; Reaction Kinetics of the Ferric Chloride Leaching of Sphalerite - An Experimental Study. Met Trans B 15B (March, 1984) pp. 5-12.

SECTION 4

Pilot Plant Design and Costing

4.1 Introduction

The scope of this section is to identify the equipment necessary for the operation of a 10 kg/h continuous pilot plant. To this end, a material balance program, based on the actual test results obtained by Bacon, Donaldson & Associates, was developed and used to size the process equipment. The equipment selected for the pilot plant is shown in Appendix B. The equipment list also indicates the size, possible manufacturer and quoted budget price for the equipment.

The installed cost for the pilot plant, shown in Section 4.4 was developed by using actual material take-offs for equipment, piping, electrical and instrumentation and estimation of the labour component for installation. Because of the scale of operation, and the disproportionate fraction of equipment costs compared to total costs, it was felt that factoring methods would be of much less accuracy than the above method.

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APPENDIX 4A

EQUIPMENT LIST

4.2 Summary

Equipment has been selected, sized and costed for the CANMET Lead-Zinc Process. The total installed cost for the pilot plant is $985,369. The accuracy of this estimate is believed to be ±10%, subject to the qualifications stated in Section 4.4.

4.3 PILOT PLANT DESIGN

4.3.1 Process Description

The temperature of operation of the leaching circuit is 108°C. To achieve this temperature at start-up it is necessary to circulate solution through the circuit, with the process tank heaters on, until the required temperatures are attained. For this purpose, a by-pass line from the first stage to the second stage leach solution tank has been provided. It is anticipated that 6 hours will be required for the initial solution preheat from ambient.

On reaching the required temperature, concentrate is metered into the first tank for the first stage leach tanks, at the rate of about 9 kg/h. Chlorinated recycle solution from the second stage leach is added such that the ratio of solids to liquids is about 0.1. The recycle solution should contain about 50 g/L of ferric ion; its flowrate is adjusted to maintain zero grams per litre in the first stage leach discharge. To assist in this objective, about 10% of the total feed rate, i.e. 1 kg/h of concentrate, is added to the last tank of the first stage leach. This acts to consume the remaining ferric ion in solution from the first two tanks.

The discharge from the first stage leach gravitates to a thickener where underflow slurry is withdrawn at about 50% solids and is pumped to the second stage leach. The thickener overflow, at about 105°C, gravitates to a pumpbox, and is pumped to the first stage leach solution tank. Solution will be allowed to accumulate in this tank during the leach campaign. A surge capacity of 24 hours has been allowed.

An inert atmosphere of nitrogen is maintained over the process solution and slurries in the first stage leach tanks, thickener, pumpbox and first stage leach solution surge tank. The gases and fumes are exhausted to a venturi type scrubber.

Recycle solution (chlorinated raffinate) from the second stage leach solution surge tank is pumped to the second stage leach tanks, such that the percent solids is about 8% in the first tank. The temperature of the leach is maintained at 108°C, with internal titanium helical coil, electrical heaters. The discharge from the second stage leach gravitates to a thickener where the underflow slurry is withdrawn at about 50% solids and is pumped to the third stage leach. The thickener overflow at about 105°C gravitates to a pumpbox and is pumped to the first stage chlorinator, and subsequently to the first stage leach tanks.

4.3.1 Process Description (cont'd)

Solution from the second stage leach solution surge tank is pumped to the third stage leach such that the percent solids in the first tank is about 20%. The temperature of the leach is maintained at 108°C by means of helical tube electrical heaters in each tank. The discharge from the third stage leach gravitates to a thickener from which underflow slurry at about 50% solids is withdrawn and pumped to the residue slurry surge tank. Slurry will be allowed to accumulate in this tank during the leach campaign. A surge capacity of 24 hours has been allowed. Overflow from the thickener gravitates to the pumpbox and is pumped to the second stage leach solution tank.

The residue filter is designed to filter one 24-hour batch of slurry in six hours. The filtered residue solids are collected and stored in drums for disposal. Filtrate and wash solution from the filter return to the second stage leach solution surge tank.

The first stage leach solution is clarified in a duplex cartridge-type filter for removal of suspended solids. The clarified solution enters the copper-silver cementation tanks, where copper and silver are precipitated from solution by the addition of lead powder. Approximately twice the stoichiometric amount of lead is required for the effective removal of the copper and silver. The precipitated solids and solution are pumped to another duplex cartridge-type filter for collection of the solids. Provision for washing of the solids on the cartridge filter is included.

The clarified solution enters the lead chloride crystallization tanks which consist of a series of four well agitated, cooled vessels. The temperature of the solution is cooled from about 100°C to 10°C by means of refrigeration coils in each tank. This causes the lead chloride to crystallize out of saturated solution. Each tank (except the first) has provision to recycle crystal slurry to the upstream tank, to promote crystal growth. The retention time in each tank is two hours. The crystal slurry is pumped to a small plate and frame pressure filter for recovery of the lead chloride crystals. The crystals are washed with dilute hydrochloric acid solution and with cold water, and collected and dried at 105°C in a tray drier. The filtrate is re-heated to about 20°C and allowed to accumulate in the solvent extraction feed tank, with a surge capacity of 24 hours.

The copper/silver cementation tanks, the lead chloride crystallization tanks and the solvent extraction feed tank are blanketed in an inert atmosphere of nitrogen, which is exhausted to the venturi scrubber.

4.3.1 Process Description (cont'd)

Zinc is removed from solution by means of solvent extraction. Four extraction stages, two scrubbing stages and four stripping stages are provided, together with settlers for the raffinate and organic. The organic comprises 25% v/v Shellsol and 75% v/v tributylphosphate (TBP).

Wash solution for wash mixer-settlers comprises acidified zinc chloride solution (from the loaded strip tank).

The zinc chloride feed solution is pumped from the surge tank to the No. 1 extraction mixer-settler (M-S), while barren organic is pumped to the No. 4 M-S. Aqueous and organic flow counter-currently until the aqueous discharges into the raffinate settler and the organic gravitates to the scrub M-S, and subsequently to the strip M-S.

The water balance in the process is maintained by taking a bleed stream from the raffinate settler tank. This bleed stream is adjusted to pH 10.5 with caustic soda to precipitate most of the heavy metals which are then filtered in a cartridge-type pressure filter. The filtrate is re-adjusted to pH 7-8 with hydrochloric acid and pumped to drain.

Strip solution is pumped from the barren strip solution tank counter-currently to the organic in the strip M-S. The barren organic gravitates to the organic settler from where it is pumped to the barren organic tank. Loaded strip solution is pumped from No. 1 strip M-S to the cementation tanks, where zinc dust and zinc oxide dust are added.

Tri-butylphosphate, as a zinc extractant is not very selective, and in addition to zinc, absorbs small quantities of lead and iron. In order to ensure the purity of the electrowon zinc, it is necessary to remove these impurities from the strip solution. Lead is removed by cementation with zinc followed by iron removal by means of zinc oxide addition. The precipitated solids are removed by pressure filtration in a duplex cartridge-type filter. The solution enters the loaded strip surge tank from the filter. This tank has a 24-hour surge capacity to allow the operation of SX campaigns independently of electrowinning.

The SX units are blanketed with an inert atmosphere of nitrogen gas.

The loaded strip solution is pumped through a carbon column for removal of the organics prior to electrowinning. The solution is then passed through the electrowinning cell where zinc is deposited on the cathode and chlorine is evolved from the anodes. The chlorine gas is removed via a fume exhaust system and absorbed in the chlorinator scrubber. The barren strip solution gravitates to the barren strip surge tank, where water make-up is added.

4.3.1 Process Description (cont'd)

The solvent extraction plant raffinate is pumped through an electrical heater to raise its temperature to 80°C. About 50% of the flow is then passed through the solution oxidation tanks for removal of excess iron by oxidation and hydrolysis. The discharge from the oxidation tanks gravitates to a pumpbox, as does the untreated portion of the raffinate stream. The mixture is then pumped through a solution heater to raise the solution temperature to about 100°C prior to entering the second stage chlorinator. The chlorinated solution is pumped to the second stage leach solution surge tank.

Solution is chlorinated by pumping the solution to a venturi-type meter which draws gaseous chlorine, under slight negative pressure, into the liquid stream. Gases and vapor from the chlorinator tanks are scrubbed with caustic soda in an off-gas scrubber. Periodically the scrub solution is pumped to a treatment tank prior to disposal.

4.3.2 Material Balance

In order to provide data for equipment sizing, a process material balance was calculated. The balance is shown in Table 4.1.

The following parameters were used in the calculations:

Feed		
Dry kg/h of Concentrate	:	10
% Lead	:	10
% Zinc	:	30
% Copper	:	0.8
% Pyrite	:	35
% Moisture	:	8
Silver Content, g/tonne	:	233

The copper was assumed to be present as a chalcopyrite. The quantity of iron dissolved in leach could not be accounted for by the quantity of iron associated with the copper. For the purpose of simulating the actual leach test results more closely, it was assumed that the zinc was present as marmatite and contained 8% ferrous sulphide.

	% Extraction in Stage			Total
	1	2	3	Extraction
Lead	99	0.5	0	99.5
Zinc	60	34	4.5	98.5
Copper	40	48	5	93.0

4.3.2 Material Balance (cont'd)

The above extraction data corresponds to that achieved by tests conducted by Bacon, Donaldson and Associates. The iron associated with chalcopyrite was assumed to leach according to the copper extractions, while the iron in marmatite was assumed to leach according to the zinc extractions.

Residue Filter Wash Ratio

1. Sodium Chloride (#14) : 2.5
2. Hot Water (#15) : 2.5

Seventy percent displacement efficiency was assumed.

Cu/Ag Cementation

Twice stoichiometric lead addition.
Filter Wash Ratio : 2.5

Lead Chloride Crystallization

Lead in Crystallizer Discharge Solution : 9 g/L
Crystal Filter Wash Ratio : 2.5

Solvent Extraction

Zinc Content in Raffinate : 4 g/L
Ratio of Organic to Scrub Solution : 40 (w/w)
Lead Absorption into Organic : 10%

Electrowinning

Zinc Content in Electrolytic Cell Discharge : 15 g/L

Solution Oxidation

Flow to Oxidation Tanks (as % of #29) : 50

In the material balance, the water balance is maintained by the bleed stream (stream 28). The iron balance is maintained by both the bleed stream and by the iron precipitated in the solution oxidation stage. The calculated material balance indicates that the bleed stream removes excessive iron from the circuit and therefore no oxidation step for the purpose of iron removal is necessary under the conditions used in this material balance. It may be necessary to consider the addition of a portion of the precipitate from the bleed stream, in order to maintain the iron balance.

To assist in the material balance calculations, a computer program was developed, which is included in Appendix 4C. The program is written in IBM BASIC and is simple to modify as required.

PROCESS STREAM DESCRIPTIONS

1. CONCENTRATE FEED
2. FIRST STAGE LEACH LIQUOR
3. FIRST STAGE LEACH DISCHARGE
4. FIRST STAGE THICKENER O/F
5. FIRST STAGE THICKENER U/F
6. SECOND STAGE LEACH LIQUOR
7. SECOND STAGE LEACH DISCHARGE
8. SECOND STAGE THICKENER O/F
9. SECOND STAGE THICKENER U/F
10. THIRD STAGE THICKENER O/F
11. THIRD STAGE THICKENER U/F
12. RESIDUE FILTRATE
13. RESIDUE DISCHARGE
14. NaCl WASH TO RESIDUE
15. HOT WATER WASH TO RESIDUE
16. CHLORINE GAS TO CHLORINATORS
17. LEAD DUST TO Cu/Ag CEMENTATION
18. CLARIFIED LEACH LIQUOR
19. CRYSTALLIZER FEED SOLUTION
20. CRYSTALLIZER DISCHARGE
21. CRYSTAL SLUDGE TO DRIER
22. CRYSTALLIZER FILTRATE
23. ZINC DUST TO CEMENTATION
24. SOLUTION TO SX SURGE TANK
25. SX FEED SOLUTION
26. BARREN ORGANIC TO EXTRACTION
27. SCRUB AQUEOUS
28. BLEED STREAM (RAFFINATE)
29. RAFFINATE
30. LOADED ORGANIC TO STRIP
31. BARREN STRIP SOLUTION
32. LOADED STRIP SOLUTION
33. PURIFIED LOADED STRIP
34. E/W FEED LIQUOR
35. CHLORINE GAS FROM E/W
36. RAFFINATE TO OXIDATION TANKS
37. RAFFINATE BY-PASS SOLUTION
38. OXYGEN TO OXIDATION TANKS
39. OXIDIZED RAFFINATE
40. CHLORINATOR FEED SOLUTION
41. CHLORINATED RECYCLE LIQUOR
42. THIRD STAGE LEACH LIQUOR
43. THIRD STAGE LEACH DISCHARGE
44. HCl WASH TO $PbCl_2$ CRYSTALS
45. COLD WATER WASH TO $PbCl_2$ CRYSTALS
46. HOT WATER WASH TO Cu/Ag CEMENT
47. NaCl WASH TO Cu/Ag CEMENT
48. VENTURI SCRUBBER WATER
49. Cu/Ag CEMENT PRODUCT
50. ZINC FROM E/W CATHODES

STREAM NUMBER :	1	2	3	4	5
Kg/h Solids	10.0	0.0	7.0	0.0	7.0
Solids Density	4.6	0.0	3.7	0.0	3.7
Kg/h Liquids	0.9	105.6	112.5	105.5	7.0
Liquids Density	1.0	1.3	1.3	1.3	1.3
Slurry Flow, L/h	3.1	79.8	85.8	78.7	7.1
LEAD					
g-mols/L	0.000	0.048	0.102	0.102	0.102
mols/h	0.0	3.8	8.6	8.0	0.5
g/L	0.0	9.9	21.2	21.2	21.2
ZINC					
g-mols/L	0.000	0.259	0.574	0.574	0.574
mols/h	0.0	20.7	48.2	45.2	3.0
g/L	0.0	16.9	37.5	37.5	37.5
COPPER					
g-mols/L	0.000	0.009	0.015	0.015	0.015
mols/h	0.0	0.7	1.2	1.2	0.1
g/L	0.0	0.6	0.9	0.9	0.9
FERROUS FE					
g-mols/L	0.000	0.025	0.905	0.905	0.905
mols/h	0.0	2.0	76.0	71.2	4.7
g/L	0.0	1.4	50.6	50.6	50.6
FERRIC FE					
g-mols/L	0.000	0.890	0.000	0.000	0.000
mols/h	0.0	71.0	0.0	0.0	0.0
g/L	0.0	49.7	0.0	0.0	0.0
NaCl					
g-mols/L	0.000	2.750	2.614	2.614	2.614
mols/h	0.0	219.4	219.4	205.7	13.7
g/L	0.0	160.7	152.7	152.7	152.7
HCl					
g-mols/L	0.000	0.386	0.366	0.366	0.366
mols/h	0.0	30.8	30.8	28.8	1.9
g/L	0.0	14.1	13.4	13.4	13.4
CHLORIDE					
g-mols/L	0.000	3.344	3.178	3.178	3.178
mols/h	0.0	266.8	266.8	250.2	16.6
g/L	0.0	118.6	112.7	112.7	112.7
WATER					
g-mols/L	55.508	52.861	52.792	52.792	52.792
mols/h	48.3	4217.0	4431.8	4155.5	276.3
g/L	1000.0	952.3	951.1	951.1	951.1

STREAM NUMBER :	6	7	8	9	10
Kq/h Solids	0.0	5.8	0.0	5.8	0.0
Solids Densitv	0.0	3.3	0.0	3.3	0.0
Kg/h Liauids	101.7	109.9	104.0	5.8	7.9
Liouids Densitv	1.3	1.3	1.3	1.3	1.3
Slurrv Flow. L/h	78.9	86.0	79.8	6.2	6.0
LEAD					
q-mols/L	0.044	0.048	0.048	0.048	0.045
mols/h	3.5	4.0	3.8	0.2	0.3
q/L	9.1	9.9	9.9	9.9	9.4
ZINC					
q-mols/L	0.041	0.259	0.259	0.259	0.334
mols/h	3.2	21.8	20.7	1.2	2.0
q/L	2.7	16.9	16.9	16.9	21.8
COPPER					
q-mols/L	0.001	0.009	0.009	0.009	0.011
mols/h	0.1	0.8	0.7	0.0	0.1
q/L	0.1	0.6	0.6	0.6	0.7
FERROUS FE					
q-mols/L	0.096	0.595	0.595	0.595	0.787
mols/h	7.6	50.2	47.5	2.7	4.7
q/L	5.4	33.2	33.2	33.2	43.9
FERRIC FE					
q-mols/L	0.796	0.320	0.320	0.320	0.138
mols/h	62.8	27.0	25.6	1.4	0.8
q/L	44.5	17.9	17.9	17.9	7.7
NaCl					
q-mols/L	2.764	2.750	2.750	2.750	2.754
mols/h	218.1	231.7	219.4	12.3	16.6
q/L	161.5	160.7	160.7	160.7	160.9
HCl					
q-mols/L	0.388	0.386	0.386	0.386	0.386
mols/h	30.6	32.5	30.8	1.7	2.3
q/L	14.1	14.1	14.1	14.1	14.1
CHLORIDE					
q-mols/L	2.752	2.774	2.774	2.774	2.757
mols/h	217.1	233.8	221.3	12.4	16.6
q/L	97.6	98.4	98.4	98.4	97.7
WATER					
q-mols/L	52.955	52.861	52.861	52.861	52.826
mols/h	4177.6	4453.9	4217.2	236.7	318.6
q/L	954.0	952.3	952.3	952.3	951.7

STREAM NUMBER :	11	12	13	14	15
Kg/h Solids	5.7	0.0	5.7	0.0	0.0
Solids Density	3.3	0.0	3.3	0.0	0.0
Kg/h Liquids	5.7	13.2	1.9	4.7	4.7
Liquids Density	1.3	1.1	1.0	1.0	1.0
Slurry Flow, L/h	6.1	11.6	3.6	4.5	4.7
LEAD					
g-mols/L	0.045	0.017	0.000	0.000	0.000
mols/h	0.2	0.2	0.0	0.0	0.0
g/L	9.4	3.5	0.0	0.0	0.0
ZINC					
g-mols/L	0.334	0.125	0.001	0.000	0.000
mols/h	1.5	1.5	0.0	0.0	0.0
g/L	21.8	8.1	0.1	0.0	0.0
COPPER					
g-mols/L	0.011	0.004	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.7	0.3	0.0	0.0	0.0
FERROUS FE					
g-mols/L	0.787	0.293	0.002	0.000	0.000
mols/h	3.4	3.4	0.0	0.0	0.0
g/L	43.9	16.4	0.1	0.0	0.0
FERRIC FE					
g-mols/L	0.138	0.052	0.000	0.000	0.000
mols/h	0.6	0.6	0.0	0.0	0.0
g/L	7.7	2.9	0.0	0.0	0.0
NaCl					
g-mols/L	2.754	1.410	0.007	1.000	0.000
mols/h	12.0	16.4	0.0	4.5	0.0
g/L	160.9	82.4	0.4	58.4	0.0
HCl					
g-mols/L	0.386	0.144	0.001	0.000	0.000
mols/h	1.7	1.7	0.0	0.0	0.0
g/L	14.1	5.2	0.0	0.0	0.0
CHLORIDE					
g-mols/L	2.757	1.028	0.007	0.000	0.000
mols/h	12.0	12.0	0.0	0.0	0.0
g/L	97.7	36.4	0.2	0.0	0.0
WATER					
g-mols/L	52.826	54.299	55.476	54.953	55.508
mols/h	229.7	632.5	104.8	245.4	262.2
g/L	951.7	978.2	999.4	990.0	1000.0

STREAM NUMBER :	16	17	18	19	20
Kg/h Solids	3.8	0.2	0.0	0.0	1.3
Solids Density	0.0	11.4	0.0	0.0	0.0
Kg/h Liquids	0.0	0.0	105.5	105.6	104.3
Liquids Density	0.0	0.0	1.3	1.3	1.3
Slurry Flow. L/h	3.8	0.0	78.7	78.8	80.1
LEAD					
g-mols/L	0.000	0.000	0.102	0.102	0.043
mols/h	0.0	0.0	8.0	8.0	3.4
g/L	0.0	0.0	21.2	21.2	9.0
ZINC					
g-mols/L	0.000	0.000	0.574	0.574	0.574
mols/h	0.0	0.0	45.2	45.2	45.2
g/L	0.0	0.0	37.5	37.5	37.5
COPPER					
g-mols/L	0.000	0.000	0.015	0.015	0.015
mols/h	0.0	0.0	1.2	1.2	1.2
g/L	0.0	0.0	0.9	0.9	0.9
FERROUS FE					
g-mols/L	0.000	0.000	0.905	0.905	0.905
mols/h	0.0	0.0	71.2	71.2	71.3
g/L	0.0	0.0	50.6	50.5	50.5
FERRIC FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
NaCl					
g-mols/L	0.000	0.000	2.614	2.612	2.612
mols/h	0.0	0.0	205.7	205.7	205.8
g/L	0.0	0.0	152.7	152.7	152.7
HCl					
g-mols/L	0.000	0.000	0.366	0.366	0.366
mols/h	0.0	0.0	28.8	28.8	28.9
g/L	0.0	0.0	13.4	13.4	13.4
CHLORIDE					
g-mols/L	0.000	0.000	3.178	3.176	3.089
mols/h	0.0	0.0	250.2	250.1	243.4
g/L	0.0	0.0	112.7	112.6	109.5
WATER					
g-mols/L	0.000	0.000	52.792	52.809	52.809
mols/h	0.0	0.0	4155.5	4159.3	4161.0
g/L	0.0	0.0	951.1	951.4	951.4

STREAM NUMBER :	21	22	23	24	25
Kg/h Solids	1.3	0.0	0.0	0.0	0.0
Solids Density	0.0	0.0	7.2	0.0	0.0
Kg/h Liquids	0.6	105.1	0.0	105.1	105.1
Liquids Density	1.1	1.3	0.0	1.3	1.3
Slurry Flow. L/h	1.8	79.6	0.0	79.6	79.6
LEAD					
g-mols/L	0.002	0.043	0.000	0.043	0.043
mols/h	0.0	3.4	0.0	3.4	3.4
g/L	0.4	8.9	0.0	8.9	8.9
ZINC					
g-mols/L	0.028	0.568	0.000	0.568	0.568
mols/h	0.0	45.2	0.0	45.2	45.2
g/L	1.8	37.1	0.0	37.1	37.1
COPPER					
g-mols/L	0.001	0.015	0.000	0.015	0.015
mols/h	0.0	1.2	0.0	1.2	1.2
g/L	0.0	0.9	0.0	0.9	0.9
FERROUS FE					
g-mols/L	0.045	0.895	0.000	0.895	0.895
mols/h	0.0	71.3	0.0	71.3	71.3
g/L	2.5	50.0	0.0	50.0	50.0
FERRIC FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
NaCl					
g-mols/L	0.129	2.602	0.000	2.602	2.602
mols/h	0.1	207.0	0.0	207.0	207.0
g/L	7.5	152.1	0.0	152.1	152.1
HCl					
g-mols/L	0.018	0.363	0.000	0.363	0.363
mols/h	0.0	28.8	0.0	28.8	28.8
g/L	0.7	13.2	0.0	13.2	13.2
CHLORIDE					
g-mols/L	0.152	3.058	0.000	3.058	3.058
mols/h	0.1	243.3	0.0	243.3	243.3
g/L	5.4	108.4	0.0	108.4	108.4
WATER					
g-mols/L	54.847	52.830	0.000	52.830	52.830
mols/h	28.4	4203.8	0.0	4203.8	4203.8
g/L	988.1	951.8	0.0	951.8	951.8

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STREAM NUMBER :     26          27          28          29          30

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Kg/h Solids        0.0         0.0         0.0         0.0         0.0

Solids Density     0.0         0.0         0.0         0.0         0.0

Kg/h Liquids     193.0         4.8        18.0        86.0       198.9

Liquids Density    1.0         1.1         1.2         1.2         1.0

Slurry Flow. L/h 198.9         4.4        14.6        69.4       205.0

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LEAD
    g-mols/L     0.000       0.000       0.037       0.037       0.002
    mols/h         0.0         0.0         0.5         2.5         0.3
    g/L            0.0         0.0         7.6         7.6         0.3
ZINC
    g-mols/L     0.031       0.607       0.061       0.061       0.238
    mols/h         6.1         2.7         0.9         4.2        48.8
    g/L            2.0        39.7         4.0         4.0        15.6
COPPER
    g-mols/L     0.000       0.000       0.014       0.014       0.000
    mols/h         0.0         0.0         0.2         1.0         0.0
    g/L            0.0         0.0         0.9         0.9         0.0
FERROUS FE
    g-mols/L     0.000       0.000       0.849       0.849       0.000
    mols/h         0.0         0.0        12.4        58.9         0.0
    g/L            0.0         0.0        47.4        47.4         0.0
FERRIC FE
    g-mols/L     0.000       0.000       0.000       0.000       0.000
    mols/h         0.0         0.0         0.0         0.0         0.0
    g/L            0.0         0.0         0.0         0.0         0.0
NaCl
    g-mols/L     0.000       0.000       2.466       2.466       0.000
    mols/h         0.0         0.0        35.9       171.1         0.0
    g/L            0.0         0.0       144.1       144.1         0.0
HCl
    g-mols/L     0.000       0.478       0.369       0.369       0.000
    mols/h         0.0         2.1         5.4        25.6         0.0
    g/L            0.0        17.4        13.4        13.4         0.0
CHLORIDE
    g-mols/L     0.000       1.214       1.935       1.935       0.000
    mols/h         0.0         5.4        28.2       134.3         0.0
    g/L            0.0        43.0        68.6        68.6         0.0
WATER
    g-mols/L     0.000      54.977      52.958      52.958       0.000
    mols/h         0.0       243.2       771.0      3675.9         0.0
    g/L            0.0       990.4       954.1       954.1         0.0
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STREAM NUMBER :	31	32	33	34	35
Kg/h Solids	0.0	0.0	0.0	0.0	2.9
Solids Densitv	0.0	0.0	0.0	0.0	0.0
Kg/h Liquids	106.4	112.2	112.2	107.3	0.0
Liquids Densitv	1.0	1.1	1.1	1.1	0.0
Slurry Flow, L/h	102.5	102.9	102.8	98.4	2.9
LEAD					
g-mols/L	0.000	0.003	0.000	0.000	0.000
mols/h	0.0	0.3	0.0	0.0	0.0
g/L	0.0	0.7	0.0	0.0	0.0
ZINC					
g-mols/L	0.219	0.603	0.607	0.607	0.000
mols/h	22.5	62.1	62.4	59.7	0.0
g/L	14.3	39.4	39.7	39.7	0.0
COPPER					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
FERROUS FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
FERRIC FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
NaCl					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
HCl					
g-mols/L	0.478	0.478	0.478	0.478	0.000
mols/h	49.0	49.2	49.2	47.1	0.0
g/L	17.4	17.4	17.4	17.4	0.0
CHLORIDE					
g-mols/L	0.439	1.213	1.214	1.214	0.000
mols/h	45.0	124.8	124.9	119.5	0.0
g/L	15.6	43.0	43.0	43.0	0.0
WATER					
g-mols/L	54.977	54.977	54.977	54.977	0.000
mols/h	5636.1	5654.8	5654.4	5411.2	0.0
g/L	990.4	990.4	990.4	990.4	0.0

STREAM NUMBER :	36	37	38	39	40
Kg/h Solids	0.0	0.0	0.0	0.0	0.0
Solids Density	0.0	0.0	0.0	0.0	0.0
Kg/h Liquids	43.0	43.0	0.0	43.0	86.0
Liquids Density	1.2	1.2	0.0	1.2	1.2
Slurry Flow. L/h	34.7	34.7	0.0	34.7	69.4
LEAD					
g-mols/L	0.037	0.037	0.000	0.037	0.037
mols/h	1.3	1.3	0.0	1.3	2.5
g/L	7.6	7.6	0.0	7.6	7.6
ZINC					
g-mols/L	0.061	0.061	0.000	0.061	0.061
mols/h	2.1	2.1	0.0	2.1	4.2
g/L	4.0	4.0	0.0	4.0	4.0
COPPER					
g-mols/L	0.014	0.014	0.000	0.014	0.014
mols/h	0.5	0.5	0.0	0.5	1.0
g/L	0.9	0.9	0.0	0.9	0.9
FERROUS FE					
g-mols/L	0.849	0.849	0.000	0.849	0.849
mols/h	29.5	29.5	0.0	29.5	58.9
g/L	47.4	47.4	0.0	47.4	47.4
FERRIC FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
NaCl					
g-mols/L	2.466	2.466	0.000	2.466	2.466
mols/h	85.6	85.6	0.0	85.6	171.1
g/L	144.1	144.1	0.0	144.1	144.1
HCl					
g-mols/L	0.369	0.369	0.000	0.369	0.369
mols/h	12.8	12.8	0.0	12.8	25.6
g/L	13.4	13.4	0.0	13.4	13.4
CHLORIDE					
g-mols/L	1.935	1.935	0.000	1.936	1.936
mols/h	67.2	67.2	0.0	67.2	134.3
g/L	68.6	68.6	0.0	68.6	68.6
WATER					
g-mols/L	52.958	52.958	0.000	52.973	52.965
mols/h	1838.0	1838.0	0.0	1838.0	3675.9
g/L	954.1	954.1	0.0	954.3	954.2

STREAM NUMBER :	41	42	43	44	45
Kg/h Solids	0.0	0.0	5.7	0.0	0.0
Solids Density	0.0	0.0	3.3	0.0	0.0
Kg/h Liquids	88.2	7.6	13.6	1.4	0.0
Liquids Density	1.3	1.3	1.3	1.0	0.0
Slurry Flow, L/h	69.1	5.9	12.1	1.3	0.0
LEAD					
g-mols/L	0.037	0.044	0.045	0.000	0.000
mols/h	2.5	0.3	0.5	0.0	0.0
g/L	7.6	9.1	9.4	0.0	0.0
ZINC					
g-mols/L	0.061	0.041	0.334	0.000	0.000
mols/h	4.2	0.2	3.5	0.0	0.0
g/L	4.0	2.7	21.8	0.0	0.0
COPPER					
g-mols/L	0.014	0.001	0.011	0.000	0.000
mols/h	1.0	0.0	0.1	0.0	0.0
g/L	0.9	0.1	0.7	0.0	0.0
FERROUS FE					
g-mols/L	0.000	0.096	0.787	0.000	0.000
mols/h	0.0	0.6	8.2	0.0	0.0
g/L	0.0	5.4	43.9	0.0	0.0
FERRIC FE					
g-mols/L	0.895	0.796	0.138	0.000	0.000
mols/h	61.8	4.7	1.4	0.0	0.0
g/L	50.0	44.5	7.7	0.0	0.0
NaCl					
g-mols/L	2.466	2.764	2.754	1.000	0.000
mols/h	170.3	16.3	28.6	1.3	0.0
g/L	144.1	161.5	160.9	58.4	0.0
HCl					
g-mols/L	0.369	0.388	0.386	0.000	0.000
mols/h	25.5	2.3	4.0	0.0	0.0
g/L	13.4	14.1	14.1	0.0	0.0
CHLORIDE					
g-mols/L	2.896	2.752	2.757	0.000	0.000
mols/h	200.0	16.2	28.6	0.0	0.0
g/L	102.7	97.6	97.7	0.0	0.0
WATER					
g-mols/L	52.965	52.955	52.826	54.953	0.000
mols/h	3657.5	311.6	548.3	71.2	0.0
g/L	954.2	954.0	951.7	990.0	0.0

STREAM NUMBER :	46	47	48	49	50
Kg/h Solids	0.0	0.0	0.0	0.2	2.6
Solids Density	0.0	0.0	0.0	10.3	7.2
Kg/h Liquids	0.1	0.0	3.0	0.1	0.0
Liquids Density	1.0	0.0	1.0	1.1	0.0
Slurry Flow, L/h	0.1	0.0	3.0	0.1	0.4
LEAD					
g-mols/L	0.000	0.000	0.000	0.005	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	1.1	0.0
ZINC					
g-mols/L	0.000	0.000	0.000	0.028	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	1.9	0.0
COPPER					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
FERROUS FE					
g-mols/L	0.000	0.000	0.000	0.045	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	2.5	0.0
FERRIC FE					
g-mols/L	0.000	0.000	0.000	0.000	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.0	0.0
NaCl					
g-mols/L	0.000	1.000	0.000	0.129	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	58.4	0.0	7.5	0.0
HCl					
g-mols/L	0.000	0.000	0.000	0.018	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	0.7	0.0
CHLORIDE					
g-mols/L	0.000	0.000	0.000	0.157	0.000
mols/h	0.0	0.0	0.0	0.0	0.0
g/L	0.0	0.0	0.0	5.6	0.0
WATER					
g-mols/L	55.508	0.000	55.508	55.374	0.000
mols/h	6.3	0.0	166.5	2.5	0.0
g/L	1000.0	0.0	1000.0	997.6	0.0

4.3.3 Design Criteria and Equipment Selection

4.3.3.1 Location

The location for the pilot plant is to be selected by Canmet. This study assumes that a flat concrete slab, under cover, heated, and adequately ventilated, with convenient access to utilities, is available. An area of approximately 160 m^2 will be required to place the equipment. Additional space for reagent storage, change facilities, lunch room, maintenance and control, etc., will be required.

4.3.3.2 Ore Characteristics

Specific gravity	
As Received	4.55
After 1st Stage Leaching	3.82
After 2nd Stage Leaching	3.40
After 3rd Stage Leaching	3.29
Moisture Content	8%
Bulk Density (estimate)	2.5 t/m^3
Composition	
Pb	10%
Zn	30%
Cu	0.8%
FeS_2	35%
FeS	3.6%
Ag	233 g/t

4.3.3.3 Leaching

Design Basis

Concentrate is leached at high temperature and atmospheric pressure with a solution comprising a mixture of primarily ferric chloride, sodium chloride and hydrochloric acid. Leaching is conducted in three stages. The discharge from each stage is thickened prior to pumping to the next stage. The primary objective of the first stage leach is to produce a leach solution which is essentially saturated with lead chloride and with all the iron in the fully-reduced state.

4.3.3.3 Leaching (cont'd)

Design Basis (cont'd)

Batch leach retention times, minutes

Stage 1	45
Stage 2	90
Stage 3	300

Design leach retention times, minutes

Stage 1	90
Stage 2	180
Stage 3	600

Number of tanks per stage

Stage 1	3
Stage 2	4
Stage 3	4

Stage 1 leachant composition, g/L

Pb	10.0
Zn	16.9
Cu	1.0
$FeCl_3$	144.4
NaCl	160.7
HCl	14.1

Leach extractions, %

	Stage			
	1	2	3	Total
Pb	99	0.5	0	99.5
Zn	60	34	4.5	98.5
Cu	40	48	5	93.0

Leach temperature (all stages), °C 108

Equipment and Materials

Concentrate Feeders: 0.14 m^3 volume pyramidal hopper feeding a 50mm diameter auger. Auger tube fabricated from H.D.P.E. Auger flight fabricated from 304 S.S. Auger driven by variable speed D.C. motor.

Leach Tanks: 350mm diameter by 800mm, fabricated from F.R.P. with a 3mm P.V.D.F. (KYNAR) lining.

- Each tank fitted with 100mm diameter, propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by 1/4 HP variable speed electric motor.
- Each tank fitted with titanium sheathed heater cap: 1.0 kW for first stage leach tanks, 0.5 kW for balance of leach tanks.
- All tanks covered, with all openings sealed. Fumes exhausted from first leach tank.
- All tanks insulated for personnel protection.

4.3.3.4 Acid Slurry Thickening and Dewatering

Design Basis

The first stage leach discharge is thickened to about 50% solids before pumping to the second stage. The thickener overflow forms the feed solution to Cu/Ag cementation.

The second stage leach discharge is thickened to about 50% solids before pumping to the third stage. After chlorination, the thickener overflow forms the leachant for the first stage leach.

The third stage leach discharge is thickened to about 50% solids before pumping to the residue filter. The thickener overflow and residue filtrate are recycled to the second stage leach.

	Thickener Stage		
	1	2	3
Solution overflow rate, L/h	78.7	79.8	10.0
Design upflow velocity, m/h	0.5	0.5	0.5

Residue Filter

- Cycle time, h	6
- Filtration rate, kg/h solids	24
- % solids	50
- Wash 1 (1M NaCl)	2.5 displacements
Wash 2 (Water)	2.5 displacements

Equipment and Materials

Settling Tanks: 915mm diameter by 470mm sidewall, with conical bottom. 6mm mild steel construction with KYNAR lining on wetted surfaces.

- Each tank c/w bridge mounted thickener mechanism fabricated from mild steel. Center shaft coated in titanium. Rake arms, rakes and feedwell coated with KYNAR.
- Each tank covered and insulated.

Pump Boxes: 500mm diameter by 500mm fabricated from F.R.P. with a 3mm KYNAR lining, covered and insulated.

Pumps: 12mm by 12mm peristaltic pump with teflon body and viton flexible liner.

- c/w 1/4 HP variable speed D.C. motor direct coupled to the pump on a common base.
- Capacity 0.02 to 0.03 L/sec.

Residue Filter: 340mm square, 3 chamber plate and frame filter press. Plates fabricated from molded KYNAR fitted with BARDAY SN4058 polypropylene filter cloth, or equivalent.

4.3.3.5 Leach Surge Capacity

Design Basis

Surge capacity is provided in the leach circuit to allow operation in campaigns independently of the remainder of the circuit.

	Surge Tank		
	1st Stage Leach	2nd Stage Leach	Residue Slurry
Volume Flow, L/h	78.7	86.7	6.1
Retention Time, h	24	24	24

Equipment and Materials

Leach Solution Surge Tanks: 1200mm diameter by 1700mm fabricated from F.R.P. with a 3mm KYNAR lining.
- Each tank fitted with 12 kW, titanium sheathed, electric resistance heater.
- Each tank covered and insulated.

Residue Slurry Surge Tank: 600mm diameter by 600mm fabricated from F.R.P. with a 3mm KYNAR lining.
- Tank fitted with 100mm diameter, prop type agitator, fabricated from mild steel with KYNAR coating, driven by 1/4 HP variable speed electric motor.
- Tank fitted with 1.5 kW, titanium sheathed electric resistance heater.
- Tank covered and insulated.

4.3.3.6 Copper-Silver Cementation

Design Basis

Copper and silver are removed from solution by precipitation with lead powder. This prevents their accumulation in the subsequent lead crystallization stage.

Volume flow, L/h	78.7
Solution composition, g/L	
Cu	1.2
Ag	0.04
Lead addition, (% of stoichiometric)	200
Batch retention time, minutes	15
Design retention time, minutes	30
Temperature, °C	105

4.3.3.6 Copper-Silver Cementation (cont'd)

Equipment and Materials

Lead Powder Feeder: 0.14 m^3 hopper and auger identical to leach circuit concentrate feeder.

Cementation Tanks: 350mm diameter by 800mm tanks identical to leach tanks, c/w agitators and a 1.5 kW electric heater in the first tank.

Pump Box and Pumps: Identical to leach circuit components.

Clarification Filters: 100mm diameter by 250mm KYNAR vessel with porous KYNAR filter element.

4.3.3.7 Lead Chloride Crystallization

Design Basis

Lead chloride will be recovered by cooling the leach liquor from about 100°C to 10°C. The crystals will be filtered, washed and dried.

Feed rate, L/h	78.8
Recycle flow, L/h	300
Composition, g/L Pb	21.2
Discharge composition, g/L Pb	9
$PbCl_2$ production, kg/h	1.27
Retention time, h	8
Temperatures, °C	
Tank 1	90
Tank 2	70
Tank 3	40
Tank 4	10
Crystal bulk density, (wet)	1.93
Filter cycle time, h	8
Wash water displacements	
Dilute HCl	2.5
Cold water	2.5

Equipment and Materials

Crystallizer Tanks: 1000mm diameter by 1000mm fabricated from F.R.P. with 3mm KYNAR lining.

- Each tank fitted with 100mm diameter, propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by 1/4 HP variable speed electric motor.
- Each tank fitted with titanium cooling coils.
- Each tank covered and vented to venturi scrubber. All openings sealed.

4.3.3.7 Lead Chloride Crystallization (cont'd)

Equipment and Materials (cont'd)

Surge Tank: 1200mm diameter by 1500mm fabricated from F.R.P.

- Covered and vented.

Leach Chloride Filter: 305mm square, 4 chamber plate and frame filter press. Plate molded from polypropylene, fitted with polypropylene cloth.

Tray Dryer: 10 shelf unit, 600mm by 370mm inside dimensions by 450mm high.

- Dryer heated with 1750 kW electric element. Air circulation provided at 300 CFM.
- Dryer constructed from 16 ga. steel (exterior) and 18 ga. 304 stainless steel (liner), with a 25mm insulating layer between.
- Temperature infinitely variable from ambient to 200°C.

Pumps: 20mm by 20mm peristaltic pump with polypropylene body and hypalon flexible liner.

- c/w 1/4 HP variable speed D.C. motor, direct coupled to the pump on a common base.
- Maximum capacity of 0.2 L/sec.

4.3.3.8 Solvent Extraction

Design Basis

Feed Liquor	
Design flow, L/h	79.6
Specific gravity	1.33
Zinc loading, g/L	37.1
Extraction	
Number of stages	4
Solvent composition, %	
- TBP	75
- Shellsol 150	25
Solvent	
- Specific gravity	0.97
- Zinc loading, g/L	15.6
- Advance flow, L/h	205
- Recycle flow, L/h	0
Mixer retention time, mins.	2.5
Settler specific flow, L/min.m^2	60.2

4.3.3.8 Solvent Extraction (cont'd)

Design Basis (cont'd)

Scrubbing	
Number of stages	2
Scrub Liquor	
Composition, g/L	
Zn	40
HCl	18
Advance flow, L/h	4.4
Recycle flow, L/h	36.6
Specific gravity	1.1
Mixer retention time, mins.	2.9
Settler specific flow, L/min.m^2	51.3
Stripping	
Number of stages	4
Strip liquor	
Composition, g/L	
Zn	15
HCl	18
Advance flow, L/h	102
Recycle flow, L/h	0
Zinc loading, g/L	40
Stripped organic - Zinc, g/L	2
Mixer retention time, mins.	2.4
Settler specific flow, L/min.m^2	64.0

Equipment and Materials

Mixer Settlers: 10 mixer-settler tanks constructed in one unit assembly, each mixer being 200mm square by 300mm deep and each settler being 200mm wide by 800mm long by 150mm deep.

- Fabricated from F.R.P.
- Each mixer fitted with 63mm diameter propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by 1/30 HP variable speed electric motor.
- Entire mixer settler covered, with seals on all penetrations.
- Liquid surface blanketed with nitrogen. Volume between liquid surface and cover vented to venturi scrubber.

Raffinate Settler Surge Tank: 1200mm diameter by 1500mm fabricated from F.R.P. c/w cover.

Barren Organic Tank: 400mm diameter by 700mm fabricated from F.R.P. c/w cover.

Raffinate Filtrate Tank: 300mm diameter by 300mm fabricated from F.R.P. c/w cover.

4.3.3.8 Solvent Extraction (cont'd)

Equipment and Materials (cont'd)

Organic Settler: 200mm wide by 800mm long by 300mm deep fabricated from F.R.P. c/w cover.

Wash Solution Make-Up Tank: 500mm diameter by 500mm fabricated from F.R.P.
- Fitted with 63mm diameter propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by 1/3 HP variable speed electric motor.
- Tank covered, with seals on all penetrations.

pH Adjustment Tank: 300mm diameter by 300mm fabricated from F.R.P.
- Fitted with 63mm diameter propeller type agitator fabricated from mild steel and coated with KYNAR. Agitator driven by 1/3 HP variable speed electric motor.
- Tank covered with seals on all penetrations.

Raffinate Filter: 100mm diameter by 250mm polypropylene vessel with porous polypropylene filter element.

Process Pumps: 20mm by 20mm peristaltic pump with polypropylene body and hypalon flexible liner.
- c/w 1/4 HP variable speed D.C. motor direct coupled on a common base.

Wash Solution Make-Up Delivery Pump: Diaphragm metering pump with KYNAR head. Manually adjusted rate from 0.012 L/sec to 0.066 L/sec.

4.3.3.9 Zinc Electrowinning

Design Basis

Loaded strip solution from SX contains impurities and traces of organic that are detrimental to the electrowinning of zinc. The loaded strip solution is first purified by removal of lead and iron followed by removal of trace organics by adsorption in a carbon column. Lead is removed by cementation with zinc, and iron by reaction with zinc oxide.

Strip liquor flowrate, L/h	98.4
Zinc addition rate, (% stoichiometric)	150
Zinc oxide addition rate, (% stoichiometric)	150
Carbon column specific flow, L/min.m^2	17
Soluble zinc concentration, g/L	40
Discharge electrolyte concentration, g/l Zn	15
Current density, A/m^2	323
Temperature, oC	25

4.3.3.9 Zinc Electrowinning (cont'd)

Design Basis (cont'd)

Electrodes	
Cathodes	Aluminum
Anodes	DSA
Effective cathode area, m^2	1.0
Power consumption, kWh/kg zinc	3.6

Equipment and Materials

Zinc Dust and Zinc Oxide Feeders: 0.14 M^3 hopper and auger identical to leach circuit concentrate feeders.

Cementation Tanks: 500mm diameter by 500mm fabricated from F.R.P.

- Each tank fitted with 100mm diameter, propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by 1/4 HP variable speed electric motor.
- Each tank covered and vented, with all openings sealed.

Clarification Filter: 100mm diameter by 250mm polypropylene vessel with porous polypropylene filter element.

Pump Box and Pump: Identical to leach circuit components.

Electrowinning Cell: 300mm by 1200mm by 1450mm deep (inside dimensions) cell fabricated from 9.5mm thick polycarbonate sheet.

- c/w one 1000mm by 1170mm aluminum cathode and two 1000mm by 1170mm DSA anodes suspended from 25mm square bus bars.
- Anode plates shrouded in polypropylene cloth bags and capped with polycarbonate hoods, to control and evacuate the chlorine gas generated during electrolysis.
- c/w 10 KVA, 600/6 volt transformer; 1000 AMP rectifier; power transmission cables, and bus bars.
- Cell hooded and evacuated to chlorine gas scrubber.

Loaded Strip Surge and Barren Strip Solution Tanks: 1200mm diameter by 1800mm tank fabricated from F.R.P., c/w cover.

Carbon Column: 350mm diameter by 1200mm column fabricated from 6mm polypropylene, fitted with a removable cover, and polypropylene filter screens on inlet and outlet.

4.3.3.9 Zinc Electrowinning (cont'd)

Equipment and Materials (cont'd)

Process Pumps: 20mm by 20mm peristaltic pump with polypropylene body and hypalon flexible liner.
- c/w 1/4 HP variable speed D.C. motor, direct coupled to the pump on a common base.

4.3.3.10 Solution Oxidation

Design Basis

The iron balance in the circuit is maintained by removal of iron from solution by means of oxidation and hydrolysis. The precipitated solids are recycled in the oxidized solution to chlorination and leaching, where they eventually discharge with the leach residue.

Solution flow to oxidation, L/h	35
Oxygen requirement (% stoichiometric)	500
Design retention time, h	6
Temperature, °C	80
Number of tanks	4

Equipment and Materials

Solution Oxidation Tanks: 400mm diameter by 800mm fabricated from F.R.P. with 3mm KYNAR lining.
- Each tank fitted with one 63mm diameter propeller type agitator fabricated from mild steel and coated with KYNAR. Agitator driven by 1/30 HP variable speed electric motor.
- Each tank fitted with a 0.5 kW electric resistance heater sheathed in titanium.
- Each tank covered and vented with all openings sealed.
- Each tank fitted with a passive gas diffuser capable of micro bubble dispersion.

Solution Heaters: One 9 kW, and one 4 kW electric resistance heater sheathed in titanium and flange connected to a 150mm diameter pipe body.

Pump Box: 500mm diameter by 500mm fabricated from F.R.P. with 3mm KYNAR lining, c/w cover.

Process Pumps: 20mm by 20mm peristaltic pump with teflon body and viton flexible liner.
- c/w 1/4 HP variable speed DC motor, direct coupled to the pump on a common base.

4.3.3.11 Chlorination

Design Basis

Second stage leach solution and recycle solution from the oxidation stage is to be chlorinated. The objective is to regenerate the ferric chloride level to about 50 g/L. The solutions are to be chlorinated by means of pumping large recycle flows through standard venturi eductor systems.

	Chlorination	
	Stage 1	Stage 2
Chlorine requirement, kg/h	2.0	1.8
Solution flow to eductor, L/min	45	45
Pressure drop across venturi, kPa	200	200
Solution flow to chlorination, L/h	80	70
Design retention time, h	4	5
Number of tanks	2	2

Equipment and Materials

Chlorination Tanks: 600mm diameter by 1100mm fabricated from F.R.P. with a 3mm KYNAR lining.

- Each tank fitted with a 100mm diameter propeller type agitator, fabricated from mild steel and coated with KYNAR. Agitator driven by a 1/4 HP variable speed electric motor.
- Each tank fitted with titanium cooling coils.
- Each tank covered, with all penetrations sealed. Fumes extracted from tank are ducted to the chlorinator off-gas scrubber through KYNAR ducts.
- Each tank insulated for personnel protection.

Chlorine Gas Feeder: Direct cylinder mount vacuum regulators, connected through an automatic switchover module, feeding chlorine gas under negative pressure to a solution actuated eductor.

Pumps: 20mm by 20mm peristaltic pump with teflon body and viton flexible liner.

- c/w 1/4 HP variable speed DC motor direct coupled to the pump on a common base.

4.3.4 Engineering

4.3.4.1 Civil Engineering

It is assumed that the pilot plant will be assembled in a building suitably sized, constructed and equipped so that no modifications are required. The only new structural items will be tank support stands, pipe racks, cable tray supports, and the electrowinning cell access platform.

4.3.4.2 Mechanical Engineering

The pilot plant layout is designed to provide maximum access to the process equipment, within the most compact reasonable area. In particular, most materials handling activities are located along the wide center aisle where hand trucks can be conveniently used. In addition, the equipment layout closely follows the process flow in order to minimize the piping requirements.

The small scale, and the single level arrangement are conducive to a very simple, straight-forward plant.

Custom equipment design is limited to the tankage, the solvent extraction mixer settlers, the electrowinning cells, and the carbon column. These items are to be fabricated in accordance with detailed sketches, drawings and data sheets. All other components are manufacturers' standard units which would be supplied in accordance with data sheets prepared by the mechanical engineers. Particular care is required in material selection to ensure reasonable component life in the very aggressive process fluids. The equipment description in Section 4.3.3 details the material selection for estimate purposes, which should be representative of the choice for the operating plant.

4.3.4.3 Piping

The piping materials selected for use in the pilot plant are:

C.P.V.C.	For process fluids at temperatures below 70°C
P.V.D.F.	For chlorine vapor and all process fluids operating at temperatures above 70°C.
Carbon Steel	For service lines (water, air, nitrogen, oxygen)

4.3.4.3 Piping (cont'd)

Length of pipe required in meters:

	Pipe Diameter				
Materials	1/2"	1"	1-1/2"	2	4"
Carbon Steel	6.7M	4.0M			
C.P.V.C.	102.9M	40.3M	2.8M	18.7M	3.1M
P.V.D.F.	92.1M	53.0M	0.6M	2.1M	

The piping will be run overhead in larger diameter pipe. Aisle cross-overs will be minimized.

4.3.4.4 Electrical Engineering

The electrical pilot plant design is based on providing a complete electrical installation including:

- power distribution
- motor control
- plant lighting
- fire alarm
- process instrumentation

Equipment includes the following:

- motor control centre (MCC)
- distribution transformer (45 KVA)
- power distribution panels (120/208 V)

It is assumed that 600/3/60 power supply is available. A power feeder will be obtained from this source. Utilization voltages of 600/3/60, and 120/208/3/60 will be distributed throughout the plant. All integral horsepower motors and electric heaters larger than 1.5 kW will be served at 600/3/60 directly from the MCC. Fractional horsepower motors, small electric heaters, lighting and miscellaneous small equipment will be served at 120 volts.

Motor control of fractional horsepower motors will consist of manual starters located near each motor. Motor control of larger motors will consist of local pushbuttons, and starters located at the MCC. Convenience receptacles will be provided for all fractional horsepower motors and small electric heaters.

Lighting will be provided by HPS luminaires. Fluorescent fixtures will be used in the MCC room.

The wiring method will be teck cable in tray.

A conventional single zone fire alarm panel, ionization type smoke detectors, manual pull stations and an audible horn are included in the design.

Process instrumentation consists of local flow indicators, local temperature indications, and temperature control thermostats.

4.4 PILOT PLANT COST ESTIMATE

A Budgetary estimate has been prepared utilizing the following information and guidelines:

- Preliminary Flowsheets.
  Sk-080-001 Rev. A - Process Block Diagram
  Sk-080-002 Rev. A - Process Flowsheet - Leach Area
  Sk-080-003 Rev. A - Process Flowsheet - Cementation and $PbCl_2$ Crystallization
  Sk-080-004 Rev. A - Process Flowsheet - Zinc Solvent Extaction Electowinning and Oxidation.

- Preliminary Plant Plot Plan.
  Sk-090-001 Rev. A - Ferric Chloride Leach Pilot Plant Plan.

  Quantity Take Offs, Equipment sizing/rating, etc., based on the Preliminary studies.

- "Statement of Work" provided by the Department of Supply and Services, of CANMET.

Qualification statements used in preparing the estimate are listed in section 4.4.1., the total installed costs are summarized in section 4.4.2.

4.4.1 Basis for Estimate

- Material/Equipment prices are 1985 preliminary vendor quotes, because most items have been single sourced, there is a possibility of cost savings if competitive bids are obtained.

- Materials and equipment have been quoted F.O.B. Saskatoon, actual freight costs will depend on geographic location of plant and availability of suppliers in that area.

- 5% Saskatchewan Sales Tax has been included where applicable. All items are assumed to be Federal Sales Tax exempt.

- Craft labour rates have been extracted from Saskatchewan Industrial Agreements.

- No travel time, transportation expenses, subsistence allowance, etc., have been included.

- An all inclusive rate of $35.00 per craft manhour has been used to calculate labour costs. This is a combination of direct and indirect costs. The direct portion being the bare hourly rate, and the indirect being craft benefits, payroll taxes, insurance, contractors mark-up, etc.

- Home office expense includes detailed engineering design, technical evaluations and specifications, procurement/ expediting services, and allocation of project support personnel as required.

4.4.1 Basis for Estimate (cont'd)

- An allowance for a floor mounted jib crane c/w electric hoist, fire equipment (no sprinkler system), safety shower/eye wash and operating supplies has been included in permanent plant facilities.
- No allowance has been made for lunch rooms, office trailer and equipment, utilities operations, snow removal, etc.
- No allowance for spare parts, or initial inventories.
- No allowance for start up and commissioning.
- Plant housing facilities are assumed to include the following:
    - A permanent concrete floor slab, heating (and winterization if required), electrical and utilities.
    - No allowance has been made for rental or leasing of such a facility.
- A minimal allowance has been made to hook up temporary facilities to permanent plant grid.
- "Building" is assumed to have existing access to accommodate largest sized equipment - no allowance is included for modifications to such.
- No allowance has been made for concrete or civil work, although equipment grouting is included.
- Permanent roof steel is assumed to be in place to allow support of overhead piping and cable trays.
- No allowance has been made for heat tracing.
- An allowance is included for an MCC room, wood or metal framed, c/w dry wall sheeting, access door and vent fan.
- No allowance is included for heating/ventilating/air conditioning system.
- Engineering and construction work is based on a regular 5 day, 40 hour work week although an allowance has been made for occasional overtime.
- No allowance has been made for special permits, licenses or fees.
- This is a preliminary estimate felt to have an accuracy of ±10%.

4.4.2 Installed Cost Estimate

STEARNS CATALYTIC

ESTIMATE SUMMARY

PROJECT. NO. 6221
CLIENT BACON, DONALDSON & ASSOCIATES
PREPARED BY: T. HAWKER DATE 85.04
LOCATION BRITISH COLUMBIA
REVISION NO. DATE
PROJECT CANMET - LEAD/ZINC PILOT PLANT
APPROVED BY DATE

ACT	DESCRIPTION	CRAFT HOURS	DIRECT HIRE LABOUR	SUB CONTRACT LABOUR	MATERIAL	EXPENSE	TOTAL
10	EARTHWORK	-	-	-	-	-	
11	CONCRETE	150	2,250	-	2,625	-	4,87
12	BUILDINGS & STRUCTURES	275	5,185	-	7,895	-	13,08
13	PROCESS EQUIPMENT	1,882	37,036	-	485,340	-	522,37
14	PIPING	1,278	24,280	-	18,330	-	42,61
15	ELECTRICAL	1,217	23,130	-	44,090	-	67,22
16	PAINTING	50	850	-	525	-	1,37
17	PLANT FACILITIES	28	530	-	11,470	-	12,00
18	CONTRACT MAINTENANCE	-	-	-	-	-	
19	INSTRUMENTS & CONTROLS	380	7,225	-	35,695	-	42,92
20	INSULATION	-	INCLUDED WITH EQUIPMENT COSTS			-	
21	SPARE PARTS	-	-	-	-	-	
22	DEMOLITION	-	-	-	-	-	
23	FIELD EXTRA'S	-	-	-	-	-	
	DIRECT FIELD COST	5,260	100,486	-	605,970	-	706,450
40	FIELD STAFF	-	-	-	-	22,000	22,000
41	CONSTRUCTION SUPPLIES	-	-	-	5,230	2,990	8,220
42	STARTUP	-	-	-	-	-	-
43	TEMPORARY FACILITIES	50	950	-	525	500	1,975
44	CRAFT BENEFITS	70	1,330	-	-	86,488	87,818
45	CONSTRUCTION CAMP	-	-	-	-	-	-
46	CONSTRUCTION EQUIPMENT	-	-	-	-	8,200	8,200
	INDIRECT FIELD COST	120	2,280	-	5,755	120,178	128,213
	TOTAL FIELD COST	5,380	102,766	-	611,725	120,187	834,669
70.1	ENGINEERING						
70.5	PROJECT MANAGEMENT						
70.7	PROCUREMENT						
70.8	PROJECT SERVICES						
70.9	EXPENSES						
	TOTAL HOME OFFICE	INCLUDES 10% CONTINGENCY					121,330
	TOTAL FIELD & HOME OFFICE						955,999
80	TAXES	INCLUDED ABOVE					
81	PREMIUM PAY	@ 10% OF D.F.L.					10,049
82	CONTINGENCY & ESCALATION						
	SUB TOTAL						966,048
90	FEES	@ 2% OF SUB TOTAL					19,320
	TOTAL						985,369

APPENDIX 4A

EQUIPMENT LIST

CLIENT: BACON, DONALDSON & ASSOCIATES
PROJECT: CANMET Pb & Zn PILOT PLANT
LOCATION: BRITISH COLUMBIA

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1302001	02001	Agitator, for First Stage Leach Tank #58001 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302002	02002	Agitator, for First Stage Leach Tank #58002 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302003	02003	Agitator, for First Stage Leach Tank #58003 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302004	02004	Agitator, for Second Stage Leach Tank #58004 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302005	02005	Agitator, for Second Stage Leach Tank #58005 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302006	02006	Agitator, for Second Stage Leach Tank #58006 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302007	02007	Agitator, for Second Stage Leach Tank #58007 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302008	02008	Agitator, for Third Stage Leach Tank #58008 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302009	02009	Agitator, for Third Stage Leach Tank #58009 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302010	02010	Agitator, for Third Stage Leach Tank #58010 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1302011	02011	Agitator, for Third Stage Leach Tank #58011 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302012	02012	Agitator, for Residue Slurry Surge Tank #58303 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 725
	1302013	02013	Agitator, for NaCl Make-Up Tank #58402 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 475
	1302014	02014	Agitator, for Cu/Ag Cementation Tank #58601 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 725
	1302015	02015	Agitator, for Cu/Ag Cementation Tank #58602 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 725
	1302017	02017	Agitator, for Pb Chloride Crystallizer Tank #21001 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302018	02018	Agitator, for Pb Chloride Crystallizer Tank #21002 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302019	02019	Agitator, for Pb Chloride Crystallizer Tank #21003 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302020	02020	Agitator, for Pb Chloride Crystallizer Tank #21004 c/w 1/4 HP Motor, 20-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 1,355
	1302021	02021	Agitator, for Lead Cementation Tank #58604 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 725

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1302024	02024	Agitator, for Zn Extraction Mixer-Settler #59001 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302025	02025	Agitator, for Zn Extraction Mixer-Settler #59002 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302026	02026	Agitator, for Zn Extraction Mixer-Settler #59003 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302027	02027	Agitator, for Zn Extraction Mixer-Settler #59004 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302028	02028	Agitator, for Zn Extraction Mixer-Settler #59005 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302029	02029	Agitator, for Zn Extraction Mixer-Settler #59006 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302030	02030	Agitator, for Wash Solution Make-Up Tank #58404 c/w 1/3 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 572
	1302031	02031	Agitator, for pH Adjustment Tank #58018 c/w 1/3 HP Motor, 1600 RPM, 115/1/60	GREEY/LIGHTNIN	$ 572
	1302033	02033	Agitator, for Zn Stripping Mixer-Settler #59007 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302034	02034	Agitator, for Zn Stripping Mixer-Settler #59008 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1302035	02035	Agitator, for Zn Stripping Mixer-Settler #59009 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302036	02036	Agitator, for Zn Stripping Mixer-Settler #59010 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 837
	1302037	02037	Agitator, for Solution Oxidation Tank #58020 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 672
	1302038	02038	Agitator, for Solution Oxidation Tank #58021 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 672
	1302039	02039	Agitator, for Solution Oxidation Tank #58022 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 672
	1302040	02040	Agitator, for Solution Oxidation Tank #58023 c/w 1/30 HP Motor, 0-1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 672
	1302043	02043	Agitator, for First Stage Chlorinator Tank #58012 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 825
	1302044	02044	Agitator, for First Stage Chlorinator Tank #58013 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 825
	1302045	02045	Agitator, for Caustic Soda Make-Up Tank #58401 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 475
	1302046	02046	Agitator, for Second Stage Chlorinator Tank #58015 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 825

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1302047	02047	Agitator, for Second Stage Chlorinator Tank #58016 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 825
	1302048	02048	Agitator, for Chlorinator Scrubber Effluent Tank #58017 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 475
	1302049	02049	Agitator, for ZnO Cementation Tank #58603 c/w 1/4 HP Motor, 1750 RPM, 115/1/60	GREEY/LIGHTNIN	$ 725
	1305001	05001	Concentrate Receiving Bin c/w 1-7/8" Auger Feeder and Variable Speed DC Drive	UNITRAK CORP. LTD.	$ 5,340
	1305002	05002	Concentrate Receiving Bin (Auxiliary) c/w 1-7/8" Auger Feeder and Variable Speed DC Drive	UNITRAK CORP. LTD.	$ 5,340
	1305101	05101	Pb Dust Hopper c/w 1-7/8" Auger Feeder and Variable Speed DC Drive	UNITRAK CORP. LTD.	$ 5,340
	1305201	05201	Zn Dust Hopper c/w 1-7/8" Auger Feeder and Variable Speed DC Drive	UNITRAK CORP. LTD.	$ 5,340
	1305202	05202	Zinc Oxide Dust Hopper c/w 1-7/8" Auger Feeder and Varible Speed DC Drive	UNITRAK CORP. LTD.	$ 5,340
	1305301	05301	Tote Box 0.1 m^3, for Pb Chloride Filter	-------	$ 20
	1310001	10001	Zn Electrolytic Cell	VENABLES MACHINE WORKS LTD.	$28,135
	1310002	10002	Zn Electrolytic Cell (Auxiliary)	VENABLES MACHINE WORKS LTD.	$28,135

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1319001	19001	JIB Crane, 1/4 Ton EL. Hoist, 360° Rotation, Monorail 2000mm Long, Free-Standing Column 3000mm High	PRAIRIE TOOL SUPPLY LTD.	$ 3,580
	1321001	21001	Pb Chloride Crystallizer, 1000mm Dia x 1000mm Sidewall Tank Fabricated from 5mm FRP & Lined with 3mm PVDF	FABRICATED PLASTICS LTD.	$ 4,950
	1321002	21002	Pb Chloride Crystallizer, 1000mm Dia x 1000mm Sidewall Tank Fabricated from 5mm FRP & Lined with 3mm PVDF	FABRICATED PLASTICS LTD.	$ 4,950
	1321003	21003	Pb Chloride Crystallizer, 1000mm Dia x 1000mm Sidewall Tank Fabricated from 5mm FRP & Lined with 3mm PVDF	FABRICATED PLASTICS LTD.	$ 4,950
	1321004	21004	Pb Chloride Crystallizer, 1000mm Dia x 1000mm Sidewall Tank Fabricated from 5mm FRP & Lined with 3mm PVDF	FABRICATED PLASTICS LTD.	$ 4,950
	1323001	23001	Pb Chloride Tray Drier	PYRADIA INC.	$ 1,995
	1328001	28001	Crystallizer Filtrate Solution Heater, Electric 4 kW	CHROMALOX	$ 4,000
	1328002	28002	Raffinate Solution Heater, Electric 9 kW	CHROMALOX	$ 5,200
	1328003	28003	Solution Heater, Oxidation, Electric 4 kW	CHROMALOX	$ 4,000
	1328101	28101	Tank Heater, Electric 0.5 kW, 13 Units Required	CHROMALOX	$ 4,680
	1328102	28102	Tank Heater, Electric 1.0 kW, 4 Units Required	CHROMALOX	$ 1,440
	1328103	28103	Tank Heater, Electric 1.5 kW, 2 Units Required	CHROMALOX	$ 720
	1328201	28201	Tank Heater, Leach Solution Surge Tank #58301, Electric Immersion, 6 kW, 2 Units Required	CHROMALOX	$ 4,090

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1328202	28202	Tank Heater, Leach Soltuion Surge Tank #58302, Electric Immersion, 6 kW, 2 Units Required	CHROMALOX	$ 4,090
	1330001	30001	Leach Residue Filter	PERRIN FILTERS LTD.	$12,360
	1330101	30101	Bleed Stream Filter	3L FILTERS LTD.	$ 440
	1330102	30102	Bleed Stream Filter	3L FILTERS LTD.	$ 440
	1330201	30201	Clarification Filter, First Stage Leach	3L FILTERS LTD.	$ 2,585
	1330202	30202	Clarification Filter, First Stage Leach	3L FILTERS LTD.	$ 2,585
	1330203	30203	Clarification Filter, Cu/Ag Cementation	3L FILTERS LTD.	$ 2,585
	1330204	30204	Clarification Filter, Cu/Ag Cementation	3L FILTERS LTD.	$ 2,585
	1330301	30301	Pb Chloride Filter	PERRIN FILTERS LTD.	$ 5,755
	1330401	30401	Clarification Filter, Pb Cementation	3L FILTERS LTD.	$ 440
	1330402	30402	Clarification Filter, Pb Cementation	3L FILTERS LTD.	$ 440
	1343001	43001	Refrigeration Unit, 2100 BTU/hr, 5 Units Titanium Immersion Coils	FLEMING-PEDLAR	$37,500
	1346001	46001	Pump, 0.03 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Settling Tank #58101	WILLIAMS HYDRONICS LTD.	1,610

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346002	46002	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58201	WILLIAMS HYDRONICS LTD.	1,610
	1346003	46003	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for First Stage Leach Solution Surge Tank #58301	WILLIAMS HYDRONICS LTD.	1,610
	1346004	46004	Pump, 0.50 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Venturi Scrubber #64001	WILLIAMS HYDRONICS LTD.	1,440
	1346005	46005	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Second Stage Leach Solution Surge Tank #58302	WILLIAMS HYDRONICS LTD.	1,610
	1346006	46006	Pump, 0.03 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Settling Tank #58102	WILLIAMS HYDRONICS LTD.	1,610
	1346007	46007	Pump, 0.03 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Settling Tank #58103	WILLIAMS HYDRONICS LTD.	1,610
	1346008	46008	Pump, 0.04 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58203	WILLIAMS HYDRONICS LTD.	1,610
	1346009	46009	Pump, 0.03 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Residue Slurry Surge Tank #58303	WILLIAMS HYDRONICS LTD.	$ 1,610

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346010	46010	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58202	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346011	46011	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for First Stage Chlorinator Tank #58013	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346012	46012	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Second Stage Chlorinator Tank #58016	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346013	46013	Pump, 0.50 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Cl Off-Gas Scrubber #64201	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346014	46014	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58204	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346015	46015	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pb Chloride Crystallizer #21002	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346016	46016	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pb Chloride Crystallizer #21003	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346017	46017	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pb Chloride Crystallizer #21004	WILLIAMS HYDRONICS LTD.	$ 1,440

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346018	46018	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, Feed to Pb Chloride Filter #30301	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346019	46019	Pump, 5.0 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Cold Water Storage Tank #58502	WILLIAMS HYDRONICS LTD.	$ 675
	1346020	46020	Pump, 0.35 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58205	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346021	46021	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Zn Solution Surge Tank #58304	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346022	46022	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Raffinate Settler #59101	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346023	46023	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, Zn Extraction Mixer Settler #59004	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346024	46024	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for pH Adjustment Tank #58018	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346025	46025	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Raffinate Filter Tank #58405	WILLIAMS HYDRONICS LTD.	$ 1,440

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346026	46026	Pump, 0.70 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Barren Organic Tank #58801	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346027	46027	Pump, 0.70 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Organic Settler #59201	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346028	46028	Pump, 0.35 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Zn Solution Strip Surge Tank #58305	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346029	46029	Pump, 0.35 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Barren Solution Strip Tank #58701	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346030	46030	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Solution Oxidation Tank #58023	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346031	46031	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Pump Box #58206 (Oxidation)	WILLIAMS HYDRONICS LTD.	$ 1,610
	1346032	46032	Pump, 5.0 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Hot Water Storage Tank #58501	WILLIAMS HYDRONICS LTD.	$ 675
	1346033	46033	Pump, 0.35 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Zn Stripping Mixer-Settler #59007	WILLIAMS HYDRONICS LTD.	$ 1,440

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346034	46034	Pump, 12 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for First Stage Chlorinator Tank #58012	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346035	46035	Pump, 12 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Second Stage Chlorinator Tank #58015	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346036	46036	Pump, 0.50 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Chlorinator Scrubber Effluent Tank #58017	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346037	46037	Pump, 0.30 GPM, c/w Variable Speed DC Drive Motor, 1/4 HP, for Crud Collecting Tank #58024	WILLIAMS HYDRONICS LTD.	$ 1,440
	1346101	46101	Metering Pump, 0.50 GPM, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60 for Caustic Soda Solution Tank #58401	FLO-CREST EQUIPMENT	$ 2,425
	1346102	46102	Metering Pump, 0.01 GPM, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60 for NaCl Make-Up Tank #58402	FLO-CREST EQUIPMENT	$ 2,425
	1346103	46103	Metering Pump, 0.01 GPM, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60 for Hydrochloric Acid Make-Up Tank #58403	FLO-CREST EQUIPMENT	$ 2,425
	1346104	46104	Metering Pump, 0.01 GPM, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60 for $ZnCl_2$/HCl Make-Up Tank #58404 (Extraction)	FLO-CREST EQUIPMENT	$ 2,425

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1346301	46301	Crud Removal Pump (Hand Operated)	------	$ 65
	1358001	58001	First Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358002	58002	First Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358003	58003	First Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358004	58004	Second Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358005	58005	Second Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358006	58006	Second Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358007	58007	Second Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358008	58008	Third Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358009	58009	Third Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358010	58010	Third Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1358011	58011	Third Stage Leach Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,035
	1358012	58012	First Stage Chlorinator Tank, 600mm Dia x 1100mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 9,235
	1358013	58013	First Stage Chlorinator Tank, 600mm Dia x 1100mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 9,235
	1358015	58015	Second Stage Chlorinator Tank, 600mm Dia x 1100mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 9,235
	1358016	58016	Second Stage Chlorinator Tank, 600mm Dia x 1100mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 9,235
	1358017	58017	Chlorinator Scrubber Effluent Tank, 500mm Dia x 500mm Sidewall, FRP	FIBERGLOSS	$ 222
	1358018	58018	pH Adjustment Tank, 300mm Dia x 300mm Sidewall, FRP	FIBERGLOSS	$ 200
	1358020	58020	Solution Oxidation Tank, 400mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,652
	1358021	58021	Solution Oxidation Tank, 400mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,652

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1358022	58022	Solution Oxidation Tank, 400mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,652
	1358023	58023	Solution Oxidation Tank, 400mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,652
	1358024	58024	Crud Collecting Tank, 500mm Dia x 500mm Sidewall, Polyethlene	CANBAR	$ 222
	1358101	58101	First Stage Settling Tank, 915mm Dia x 470mm Sidewall, w/ Cone Bottom 6mm Mild Steel Coated with Kynar Liner	DORR-OLIVER	See Equipment #59301
	1358102	58102	Second Stage Settling Tank, 915mm Dia x 470mm Sidewall, w/ Cone Bottom 6mm Mild Steel Coated with Kynar Liner	DORR-OLIVER	See Equipment #59302
	1358103	58103	Third Stage Settling Tank, 915mm Dia x 470mm Sidewall, w/ Cone Bottom 6mm Mild Steel Coated with Kynar Liner	DORR-OLIVER	See Equipment #59303
	1358201	58201	Pump Box, First Stage Leach, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040
	1358202	58202	Pump Box, Second Stage Leach, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040
	1358203	58203	Pump Box, Third Stage Leach, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040
	1358204	58204	Pump Box, Cu/Ag Cementation, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040
	1358205	58205	Pump Box, Pb Cementation, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1358206	58206	Pump Box, Solution Oxidation, 500mm Dia x 500mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,040
	1358301	58301	First Stage Leach Solution Surge Tank, 1200mm Dia x 1700mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 5,980
	1358302	58302	Second Stage Leach Solution Surge Tank, 1200mm Dia x 1700mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 5,980
	1358303	58303	Residue Slurry Surge Tank, 600mm Dia x 600mm Sidewall with Baffles, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,070
	1358304	58304	Zn Solution Surge Tank, 1200mm Dia x 1500mm Sidewall, FRP	FIBERGLOSS	$ 2,050
	1358305	58305	Loaded Strip Surge Tank, 1200mm Dia x 1800mm Sidewall, FRP	FIBERGLOSS	$ 2,450
	1358401	58401	Caustic Soda Solution Tank, 500mm Dia x 500mm Sidewall, Polyethlene	CANBAR	$ 222
	1358402	58402	NaCl Make-Up Tank, 500mm Dia x 500mm Sidewall, FRP	FIBERGLOSS	$ 1,000
	1358403	58403	Hydrochloric Acid Make-Up Tank, 500mm Dia x 500mm Sidewall, Polyethlene	CANBAR	$ 222

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1358404	58404	Wash Solution Make-Up Tank, 500mm Dia x 500mm Sidewall, Polyethlene	CANBAR	$ 222
	1358405	58405	Raffinate Filtrate Tank, 300mm Dia x 300mm Sidewall, FRP	FIBERGLOSS	$ 200
	1358501	58501	Hot Water Storage Tank, 500mm Dia x 500mm Sidewall, FRP	FIBERGLOSS	$ 1,000
	1358502	58502	Cold Water Storage Tank, 500mm Dia x 500mm Sidewall, Polyethlene	CANBAR	$ 222
	1358601	58601	Cu/Ag Cementation Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,125
	1358602	58602	Cu/Ag Cementation Tank, 350mm Dia x 800mm Sidewall, FRP with PVDF Lining	FABRICATED PLASTICS LTD.	$ 2,125
	1358603	58603	ZnO Cementation Tank, 500mm Dia x 500mm Sidewall, FRP	FIBERGLOSS	$ 1,000
	1358604	58604	Pb Cementation Tank, 500mm Dia x 500mm Sidewall, FRP	FIBERGLOSS	$ 1,000
	1358701	58701	Barren Strip Solution Tank, 1200mm Dia x 1800 mm Sidewall, FRP	FIBERGLOSS	$ 2,450
	1358801	58801	Barren Organic Tank, 400mm Dia x 700mm Sidewall, FRP	FIBERGLOSS	$ 350

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1358802	58802	Crud Collecting Tank, 400mm Dia x 700mm Sidewall, FRP	FIBERGLOSS	$ 350
	1359001	59001	Zn Extraction Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359002	59002	Zn Extraction Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359003	59003	Zn Extraction Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359004	59004	Zn Extraction Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359005	59005	Organic Wash Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359006	59006	Organic Wash Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1359007	59007	Zn Stripping Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359008	59008	Zn Stripping Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359009	59009	Zn Stripping Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359010	59010	Zn Stripping Mixer-Settler, 200mm Square x 300mm Sidewall, /200mm Wide x 150mm Deep x 800mm Long FRP	FIBERGLOSS	$ 1,780
	1359101	59101	Raffinate Settler, Surge Tank, 1200mm Dia x 1500mm FRP	FIBERGLOSS	$ 2,160
	1359201	59201	Organic Settler, Extraction, 200mm W x 300mm H x 800mm L FRP	FIBERGLOSS	$ 690
	1359301	59301	Thickener Mechanism, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60, Center Shaft Titanium Coated, Rakes, Drive, Feed Well, Cover & Support for First Stage Settling Tank #58101	DORR-OLIVER CANADA LTD.	$10,000

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AREA	ACC'T NO.	EQUIP. NO.	EQUIPMENT NAME & DESCRIPTION	SUPPLIER	UNIT PRICE
	1359302	59302	Thickener Mechanism, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60, Center Shaft Titanium Coated, Rakes, Drive, Feed Well, Cover & Support for Second Stage Settling Tank #58102	DORR-OLIVER CANADA LTD.	$10,000
	1359303	59303	Thickener Mechanism, c/w Motor, 1/4 HP, 1800 RPM, 115/1/60, Center Shaft Titanium Coated, Rakes, Drive, Feed Well, Cover & Support for Third Stage Settling Tank #58103	DORR-OLIVER CANADA LTD.	$10,000
	1360001	60001	Carbon Adsorption Column	FABRICATED PLASTICS LTD.	$ 1,650
	1364001	64001	Venturi Scrubber, c/w Fan, 600 CFM, 12" W.G. Motor, 5 HP, 3600 RPM, 575/5/60	CEILCOTE CANADA LTD.	$ 7,200
	1364201	64201	Chlorinator Off-Gas Scrubber, c/w Fan, 600 CFM, 4" W.G., Motor, 1.5 HP, 3600 RPM, 575/3/60	CEILCOTE CANADA LTD.	$10,950

APPENDIX 4B

MATERIAL BALANCE PROGRAM

```
10 ' ON ERROR GOTO
 15000
50 DEFDBL A - Z
60 DEFINT I.J.K
70 KEY OFF
100 :REM                    CANMET LEAD ZINC PROCESS
110 :
120 :REM                      MASS BALANCE PROGRAM
130 :
140 ' Written bv Alan M. Childs. P.Eng                      March. 1985
150 ' Stearns Catalvtic Ltd.. Saskatoon
160 ' tel (306) 664 8811
170 '
190 :REM NOMENCLATURE OF ARRAYS
195 :
200 :REM T  :T/D SOLIDS
210 :REM L  :T/D LIQUIDS
220 :REM SD :SOLIDS DENSITY. T/M3
230 :REM LD :LIQUIDS DENSITY. T/M3
250 :REM F2 :MOLS/M3 FE2+ IN LIQUIDS
260 :REM F3 :MOLS/M3 FE3+ IN LIQUIDS
275 :REM C2 :MOLS/M3 CUPRIC IN LIQUIDS
270 :REM C1 :MOLS/M3 CUPROUS IN LIQUIDS
300 :REM PB :MOLS/M3 LEAD IN LIQUIDS
305 :REM ZN :MOLS/M3 ZINC IN LIQUIDS
310 :REM W  :MOLS/M3 WATER IN LIQUIDS
320 :REM NA :MOLS/M3 NaCL IN LIQUIDS
330 :REM H  :MOLS/M3 HCL IN LIQUIDS
340 :REM CL :MOLS/M3 CHLORIDE IN LIQUIDS
350 :
360 :
400 CU = 63.54   :REM MW OF COPPER
410 PB = 207.19  :REM MW OF LEAD
420 S  = 32.064  :REM MW OF SULPHUR
430 FE = 55.847  :REM MW OF IRON
440 CL = 35.453  :REM MW OF CHLORINE
450 OX = 15.9994 :REM MW OF OXYGEN
460 ZN = 65.37   :REM MW OF ZINC
470 NA = 22.9898 :REM MW OF SODIUM
480 AG = 107.87  :REM MW OF SILVER
490 H  = 1.00797 :REM MW OF HYDROGEN
495 :
500 DIM T(60),L(60),SD(60),LD(60),F2(60),F3(60),C1(60),C2(60),W(60),PB(60)
510 DIM ZN(60),CL(60),H(60),NA(60),C(60)
520 :
530 CLS : LOCATE 10.22 : PRINT"CANMET LEAD - ZINC RECOVERY PROCESS"
535 FOR J=1 TO 2000:NEXT J
540 READ T(1),LEAD,ZINC,COPPER,PYRITE,M,SILVER,EXPB1,EXPB2,EXPB3,EXPB,EXZN1,EXZ
2,EXZN3,EXZN,EXCU1,EXCU2,EXCU3,EXCU
550 CLS:PRINT"THE MASS BALANCE WILL BE CALCULATED USING THE FOLLOWING DATA :"
560 LOCATE 3,1:PRINT"FEED COMPOSITION (DRY BASIS)"
570 LOCATE 5,10:PRINT"                       1. DRY KILOGRAMS PER HOUR    :";T(1)
580 LOCATE 7,10:PRINT"                       2.  - PERCENT LEAD           :";LEAD
590 LOCATE 9,10:PRINT"                       3.  - PERCENT ZINC           :";ZINC
600 LOCATE 11,10:PRINT"                       4.  - PERCENT COPPER         :";COPPER
610 LOCATE 13,10:PRINT"                       5.  - PERCENT PYRITE         :";PYRITE
620 LOCATE 15,10:PRINT"                       6.  - PERCENT MOISTURE       :";M
630 LOCATE 17,10:PRINT"                       7.  - SILVER IN FEED, G/TONNE:";SILVER
```

```
640 LOCATE 19.10:PRINT"                        8.  - REVIEW RECOVERY DATA   "
650 A$ = INKEY$: IF A$ = CHR$(13) THEN 1200
700 LOCATE 21.1:PRINT"ENTER NUMBER TO CHANGE DATA. ELSE PRESS 'RETURN' TO CONTIN
UE"
720 IF A$ = CHR$(49) THEN LOCATE 5.57: PRINT"          ":LOCATE 5.57 : INPUT T(1)
: GOTO 1000
730 IF A$ = CHR$(50) THEN LOCATE 7.57: PRINT"          ":LOCATE 7.57 : INPUT LEAD
: GOTO 1000
740 IF A$ = CHR$(51) THEN LOCATE 9.57: PRINT"          ":LOCATE 9.57 : INPUT ZINC
: GOTO 1000
750 IF A$ = CHR$(52) THEN LOCATE 11.57: PRINT"          ":LOCATE 11.57 : INPUT CO
PPER: GOTO 1000
760 IF A$ = CHR$(53) THEN LOCATE 13.57: PRINT"          ":LOCATE 13.57 : INPUT PY
RITE: GOTO 1000
770 IF A$ = CHR$(54) THEN LOCATE 15.57: PRINT"          ":LOCATE 15.57 : INPUT M
: GOTO 1000
780 IF A$ = CHR$(55) THEN LOCATE 17.57: PRINT"          ":LOCATE 17.57 : INPUT SI
LVER : GOTO 1000
790 IF A$ = CHR$(56) THEN GOSUB 800 : GOTO 550
795 GOTO 1000
800 CLS:LOCATE 4.30 :PRINT "LEACH EXTRACTION DATA"
810 LOCATE 6.23 :PRINT"STAGE 1          STAGE 2          STAGE 3          OVERALL"
815 LOCATE 7.1 :PRINT"------------------------------------------------------------
------------------------"
820 LOCATE 9.10 :PRINT"LEAD          ";EXPB1;SPC(12)EXPB2;SPC(12)EXPB3;SPC(9)EXPB

830 LOCATE 11,10 :PRINT"ZINC          ";EXZN1;SPC(12)EXZN2;SPC(12)EXZN3;SPC(9)EXZ
N
840 LOCATE 13,10 :PRINT"COPPER        ";EXCU1;SPC(12)EXCU2;SPC(12)EXCU3;SPC(9)EXC
U
850 LOCATE 15.1 :PRINT"------------------------------------------------------------
------------------------"
860 LOCATE 17.1:PRINT"ENTER L(EAD), Z(INC), OR C(OPPER) TO CHANGE DATA"
865 B$=INKEY$ : IF B$ = CHR$(13) THEN RETURN
870 IF B$="L" OR B$="Z" OR B$="C" THEN LOCATE 19.1: PRINT "ENTER STAGE NUMBER 1.
 2. OR 3" ;: INPUT NS : GOTO 900
880 LOCATE 17.1 :PRINT"                                                             "
890 GOTO 860
900 LOCATE 19.1 : PRINT"                                                            "
902 IF B$="L" AND NS=1 THEN LOCATE 9.20:PRINT"            ";:LOCATE 9.23:INPUT EX
: E = EX+EXPB2+EXPB3 :IF E > 100 THEN LOCATE 9.23:PRINT EXPB1 ELSE EXPB1=EX:LOCA
TE 9.64 :PRINT"          ";:EXPB=E:LOCATE 9,67:PRINT EXPB : GOTO 860
905 IF B$="L" AND NS=2 THEN LOCATE 9.35:PRINT"            ";:LOCATE 9.38:INPUT EX
: E = EXPB1+EX+EXPB3 :IF E > 100 THEN LOCATE 9.38:PRINT EXPB2 ELSE EXPB2=EX:LOCA
TE 9.64 :PRINT"           ";:EXPB=E:LOCATE 9,67:PRINT EXPB : GOTO 860
910 IF B$="L" AND NS=3 THEN LOCATE 9.50:PRINT"            ";:LOCATE 9.53:INPUT EX
: E = EXPB1+EXPB2+EX :IF E > 100 THEN LOCATE 9.53:PRINT EXPB3 ELSE EXPB3=EX:LOCA
TE 9.64 :PRINT"           ";:EXPB=E:LOCATE 9.67:PRINT EXPB : GOTO 860
915 :
920 IF B$="Z" AND NS=1 THEN LOCATE 11.20:PRINT"           ";:LOCATE 11,23:INPUT
EX: E = EX+EXZN2+EXZN3 :IF E > 100 THEN LOCATE 11,23:PRINT EXZN1 ELSE EXZN1=EX:L
OCATE 11,64 :PRINT"          ";:EXZN=E:LOCATE 11,67:PRINT EXZN : GOTO 860
925 IF B$="Z" AND NS=2 THEN LOCATE 11,35:PRINT"           ";:LOCATE 11.38:INPUT
EX: E = EXZN1+EX+EXZN3 :IF E > 100 THEN LOCATE 11.38:PRINT EXZN2 ELSE EXZN2=EX:L
OCATE 11,64 :PRINT"          ";:EXZN=E:LOCATE 11,67:PRINT EXZN : GOTO 860
930 IF B$="Z" AND NS=3 THEN LOCATE 11.50:PRINT"           ";:LOCATE 11,53:INPUT
EX: E = EXZN1+EXZN2+EX :IF E > 100 THEN LOCATE 11,53:PRINT EXZN3 ELSE EXZN3=EX:L
OCATE 11,64 :PRINT"          ";:EXZN=E:LOCATE 11,67:PRINT EXZN : GOTO 860
```

```
935 :
940 IF B$="C" AND NS=1 THEN LOCATE 13.20:PRINT"              ";:LOCATE 13,23:INPUT
EX: E = EX+EXCU2+EXCU3 :IF E > 100 THEN LOCATE 13,23:PRINT EXCU1 ELSE EXCU1=EX:L
OCATE 13,64 :PRINT"              ";:EXCU=E:LOCATE 13,67:PRINT EXCU : GOTO 860
945 IF B$="C" AND NS=2 THEN LOCATE 13,35:PRINT"              ";:LOCATE 13.38:INPUT
EX: E = EXCU1+EX+EXCU3 :IF E > 100 THEN LOCATE 13,38:PRINT EXCU2 ELSE EXCU2=EX:L
OCATE 13,64 :PRINT"              ";:EXCU=E:LOCATE 13,67:PRINT EXCU : GOTO 860
950 IF B$="C" AND NS=3 THEN LOCATE 13.50:PRINT"              ";:LOCATE 13.53:INPUT
EX: E = EXCU1+EXCU2+EX :IF E > 100 THEN LOCATE 13.53:PRINT EXCU3 ELSE EXCU3=EX:L
OCATE 13.64 :PRINT"              ";:EXCU=E:LOCATE 13.67:PRINT EXCU : GOTO 860
960 :
990 GOTO 860
1000 LOCATE 21.1:PRINT"
   "
1110 GOTO 650
1120 DATA 10,10,30,0.8,35, 8,233
1130 DATA 99,0.5,0,99.5
1140 DATA 60,34,4.5,98.5
1150 DATA 40,48,5 ,93
1160 :
1200 D1 = 4.1 : 'ZnS
1210 D2 = 7.5 : 'PbS
1220 D3 = 4.2 : 'CuFeS2
1230 D4 = 5! : 'FeS2
1240 D5 = 2.6 : 'GANGUE
1250 D6 = 2! : 'SULPHUR
1260 D7 = 4.5: 'FeS
1290 :
1300 PBS = LEAD*(PB+S)/PB                 '% PbS
1310 ZNS = ZINC*(ZN+S)/ZN                 '% ZnS
1315 FES = .08 * ZNS                      '% FeS in Marmatite
1320 CUFES = COPPER*(FE+CU+2*S)/CU        '% CuFeS2
1330 GANGUE = 100 - PBS -ZNS - FES - CUFES - PYRITE : B$ = "###.##"
1331 CLS : LOCATE 5,30:PRINT"FEED COMPOSITION":LOCATE 7,10:PRINT"% LEAD SULPHIDE
    = ";USING B$;PBS:LOCATE 9,10:PRINT"% ZINC SULPHIDE    = ";USING B$;ZNS:LOCAT
E 11,10:PRINT"% FERROUS SULPHIDE = ";USING B$;FES
1332 LOCATE 13,10:PRINT"% CHALCOPYRITE      = ";USING B$;CUFES : LOCATE 15,10:PRI
NT"% PYRITE            = ";USING B$;PYRITE : LOCATE 17,10:PRINT"% GANGUE
  = ";USING B$;GANGUE
1333 IF GANGUE < 0 THEN LOCATE 20,25 :PRINT"RE-ADJUST COMPOSITION":FOR I=1 TO 90
00:NEXT:GOTO 550
1334 LOCATE 20,25:PRINT"CALCULATIONS IN PROGRESS"
1340 SD(1) = 100/(ZNS/D1 + PBS/D2 + CUFES/D3 + PYRITE/D4 + GANGUE/D5 + FES/D7)
1350 LD(1) = 1
1360 L(1) = T(1)/((100-M)/100) - T(1)
1370 W(1) = 1000/(H*2 + OX)
1380 :
1400 PB1 = T(1) * (LEAD/100) * 1000 / PB             'g-mols Pb / h
1405 ZN1 = T(1) * (ZINC/100) * 1000 / ZN             'g-mols Zn / h
1410 CU1 = T(1) * (COPPER/100) * 1000 / CU           'g-mols Cu / h
1412 FEZN1 = T(1) * (FES/100) * 1000 / (FE + S)      'g-mols Fe / h (soluble)
1415 FE1 = CU1 + FEZN1                               'g-mols Fe / h (soluble)
1416 :
1420 PB5 = (1-EXPB1/100)*PB1
1425 ZN5 = (1-EXZN1/100)*ZN1
1430 CU5 = (1-EXCU1/100)*CU1
1433 FEZN5 = (1-EXZN1/100)*FEZN1
1435 FE5 = CU5 + FEZN5
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1436 :
1440 PB9 = (1-(EXPB1+EXPB2)/100)*PB1
1445 ZN9 = (1-(EXZN1+EXZN2)/100)*ZN1
1450 CU9 = (1-(EXCU1+EXCU2)/100)*CU1
1453 FEZN9 = (1-(EXZN1+EXZN2)/100)*FEZN1
1455 FE9 = CU9 + FEZN9
1456 :
1460 PB11 = (1-EXPB/100)*PB1
1465 ZN11 = (1-EXZN/100)*ZN1
1470 CU11 = (1-EXCU/100)*CU1
1473 FEZN11 = (1-EXZN/100)*FEZN1
1475 FE11 = CU11 + FEZN11
1476 :
1477 'WEIGHT LOSSES IN EACH LEACH STAGE
1478 :
1480 WL1 = ((PB1-PB5)*PB + (ZN1-ZN5)*ZN + (CU1-CU5)*CU + (FE1-FE5)*FE)/1000
1485 T(3) = T(1) - WL1 :T(5) = T(3)
1490 WL2 = ((PB5-PB9)*PB + (ZN5-ZN9)*ZN + (CU5-CU9)*CU + (FE5-FE9)*FE)/1000
1495 T(7) = T(5) - WL2 :T(9) = T(7)
1500 WL3 = ((PB9-PB11)*PB + (ZN9-ZN11)*ZN + (CU9-CU11)*CU + (FE9-FE11)*FE)/1000
1505 T(11) = T(9) - WL3 :T(13) = T(11)
1506 :
1510 SD(3) = T(3)/( T(1)/SD(1) - ( (PB1-PB5)*(PB+S)/D2 + (ZN1-ZN5)*(ZN+S)/D1 + (
FEZN1-FEZN5)*(FE+S)/D7 + (CU1-CU5)*(CU+FE+2*S)/D3 - ( (PB1-PB5)+(ZN1-ZN5)+(FEZN1
-FEZN5)+2*(CU1-CU5) )*S/D6 )/1000)
1515 SD(5) = SD(3)
1520 SD(7) = T(7)/( T(3)/SD(3) - ( (PB5-PB9)*(PB+S)/D2 + (ZN5-ZN9)*(ZN+S)/D1 + (
FEZN5-FEZN9)*(FE+S)/D7 + (CU5-CU9)*(CU+FE+2*S)/D3 - ( (PB5-PB9)+(ZN5-ZN9)+(FEZN5
-FEZN9)+2*(CU5-CU9) )*S/D6 )/1000)
1525 SD(9) = SD(7)
1530 SD(11) = T(11)/( T(9)/SD(9) - ( (PB9-PB11)*(PB+S)/D2 + (ZN9-ZN11)*(ZN+S)/D1
 + (FEZN9-FEZN11)*(FE+S)/D7 + (CU9-CU11)*(CU+FE+2*S)/D3 - ( (PB9-PB11)+(ZN9-ZN11
)+(FEZN9-FEZN11)+2*(CU9-CU11) )*S/D6 )/1000)
1535 SD(13) = SD(11)
1700 'INITIAL GUESS FOR RECYCLE SOLUTION COMPOSITION FROM 2cnd STAGE CHLORINATOR

1705 :
1710 PB(0) = 10                            : Z = PB(0)
1715 ZN(0) = 0
1720 C1(0) = 0
1725 C2(0) = 0
1730 F2(0) = 0
1735 F3(0) = 55                                  :  Z = Z + F3(0)
1740 NA(0) = 175.329                             :  Z = Z + NA(0)
1745 H(0)  = 15.6782                             :  Z = Z + H(0)
1748 CL(0) = 3*F3(0)*CL/FE + 2*PB(0)*CL/PB :  Z = Z + CL(0)
1750 W(0)  = 950                                 :  Z = Z + W(0)
1751 LD(0) = Z/1000
1752 PB(6) = PB(0)/PB
1753 ZN(6) = ZN(0)/ZN
1754 C1(6) = C1(0)/CU
1755 C2(6) = C2(0)/CU
1756 F2(6) = F2(0)/FE
1760 F3(6) = F3(0)/FE              'g-mols Fe3+ per litre
1765 NA(6) = NA(0)/(NA + CL)       'g-mols NaCl per litre
1770 H(6)  = H(0)/(H + CL)         'g-mols HCl  per litre
1775 W(6)  = W(0)/(H*2 + OX)       'g-mols H2O  per litre
1778 CL(6) = 3*F3(6)+2*PB(6)       'g-mols Cl-  per litre
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1780 LD(6) = LD(0)
1782 J=41 : K = 6 :GOSUB 17000
1783 LD(41) = LD(6)
1785 :
1810 'INITIAL GUESS 1st STAGE LEACH SOLUTION
1815 :
1820 PB(2) = 12/PB                                  : Z =     PB(2) * PB
1830 ZN(2) = (12*ZINC/LEAD)/ZN                      : Z = Z + ZN(2) * ZN
1835 C1(2) = 0                                      : Z = Z + C1(2) * CU
1840 C2(2) = (12*COPPER/LEAD)/CU                    : Z = Z + C2(2) * CU
1850 F2(2) = C2(2)                                  : Z = Z + F2(2) * FE
1860 F3(2) = 50/FE                                  : Z = Z + F3(2) * FE
1870 NA(2) = 175.329/(NA + CL)                      : Z = Z + NA(2) * (NA+CL)
1880 H(2) = 15.678/(H + CL)                         : Z = Z +  H(2) * (H+CL)
1890 CL(2) = 2*(PB(2)+ZN(2)+C2(2)+F2(2))+F3(2)*3    : Z = Z + CL(2) * CL
1900 W(2) = 1331 - Z                                : Z = Z + W(2)
1910 W(2) = W(2) / (H*2 + OX)
1920 LD(2) = Z/1000
1930 :
1940 L(48)=0 : LD(48)=1 : W(48)=1000/(H*2+OX) : G3=L(48)/LD(48)
2000 L(48)=3 : LD(48)=1 : W(48)=1000/(H*2+OX) : G3=L(48)/LD(48)
2005 C1 = 2*( (PB1-PB5) + (ZN1-ZN5) + (FEZN1-FEZN5) ) + 3*(CU1-CU5)   'mols Fe3+
read in stg 1
2010 :
2020 L(2) = C1*LD(2)/F3(2)
2040 L(3) = L(1) + L(2) + T(1) - T(3)
2050 LD(3) = L(3)/(L(1)/LD(1) + L(2)/LD(2) + T(1)/SD(1) - T(3)/SD(3))
2060 :
2100 G1 = L(2)/LD(2)  :  G2 = L(3)/LD(3)
2110 PB(3) = (PB(2)*G1 + (PB1-PB5))/G2
2120 ZN(3) = (ZN(2)*G1 + (ZN1-ZN5))/G2
2125 C1(3) = (C1(2)*G1 + (CU1-CU5))/G2
2130 C2(3) = C2(2)*G1/G2
2140 F2(3) = ( F2(2)*G1 + (FE1-FE5) + C1 )/G2
2150 F3(3) = (F3(2)*G1 - C1)/G2
2160 NA(3) = NA(2)*G1/G2
2170 H(3)  = H(2)*G1/G2
2180 CL(3) = CL(2)*G1/G2
2190 W(3)  = (W(2)*G1 + W(1)*L(1)/LD(1))/G2
2195 :
2200 W(3) = (W(3)*G2+W(48)*G3)/(G2+G3)
2210 LD(3) = (L(3) + L(48))/(G2 + G3)
2220 L(3) = L(3) + L(48)
2230 G4 = L(3)/LD(3)
2240 PB(3) = PB(3)*G2/G4
2250 ZN(3) = ZN(3)*G2/G4
2260 C1(3) = C1(3)*G2/G4
2270 C2(3) = C2(3)*G2/G4
2280 F2(3) = F2(3)*G2/G4
2290 F3(3) = F3(3)*G2/G4
2300 NA(3) = NA(3)*G2/G4
2310 H(3)  = H(3)*G2/G4
2320 CL(3) = CL(3)*G2/G4
2400 L(5) = T(5) :           LD(5) = LD(3)
2410 L(4) = L(3) - L(5)  :   LD(4) = LD(3)
2460 :
2470 J=4 : K=3 : GOSUB 17000
2480 J=5 : K=4 : GOSUB 17000
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2620 :
2630 C2 = 2*( (PB5-PB9) + (ZN5-ZN9) + (FEZN5-FEZN9) ) + 3*(CU5-CU9) 'mols Fe3+ r
ead in stg 2
2640 :
2650 L(6) = T(5)*92/8 - L(5)             ' initial guess
2700 L(7) = L(5) + L(6) + T(5) - T(7)
2710 LD(7) = L(7)/(L(5)/LD(5) + L(6)/LD(6) + T(5)/SD(5) - T(7)/SD(7))
2800 :
2810 G1 = L(5)/LD(5) : G2 = L(6)/LD(6) : G3 = L(7)/LD(7)
2920 PB(7) = (PB(5)*G1 + PB(6)*G2 + (PB5 - PB9))/G3
2830 ZN(7) = (ZN(5)*G1 + ZN(6)*G2 + (ZN5 - ZN9))/G3
2940 C1(7) = (C1(5)*G1 + C1(6)*G2 + (CU5 - CU9))/G3
2850 C2(7) = (C2(5)*G1 + C2(6)*G2)/G3
2860 F2(7) = (F2(5)*G1 + F2(6)*G2 + (FE5 - FE9) + C2)/G3
2870 F3(7) = (F3(5)*G1 + F3(6)*G2 - C2)/G3
2880 NA(7) = (NA(5)*G1 + NA(6)*G2)/G3
2890 H(7)  = (H(5) *G1 + H(6) *G2)/G3
2900 CL(7) = (CL(5)*G1 + CL(6)*G2)/G3
2910 W(7)  = (W(5) *G1 + W(6) *G2)/G3
3000 L(9) = T(9)            : LD(9) = LD(7)
3010 L(8) = L(7) - L(9)     : LD(8) = LD(7)
3020 :
3030 J=8 : K=7 : GOSUB 17000
3040 J=9 : K=7 : GOSUB 17000
3130 :
3200 C4 = C1 - F3(8)*L(8)/LD(8) 'additional Fe3+ required in stream #2
3210 ' C4 also = mols/h Cl required : FeCl2 + Cl = FeCl3
3215 IF F2(8)*L(8)/LD(8) < C4 THEN C4 = F2(8)*L(8)/LD(8)
3220 C5 = L(8) + C4 * CL/1000    'net solution weight in #2
3230 IF ABS(L(2)-C5) > .00001 THEN L(6) = L(6) + (L(2) - C5) : GOTO 2700
3250 :
3300 G1 = L(8)/LD(8)   :  C6 = LD(2)
3310 PB(2) = PB(8)
3320 ZN(2) = ZN(8)
3330 C1(2) = C1(8)
3340 C2(2) = C2(8)
3350 F2(2) = (F2(8)*G1 - C4)/G1
3360 F3(2) = (F3(8)*G1 + C4)/G1
3370 NA(2) = NA(8)
3380 H (2) = H (8)
3390 CL(2) = (CL(8)*G1 + C4)/G1
3400 W (2) = W (8)
3410 Y=2 :GOSUB 18000
3420 PRINT
3450 IF ABS(LD(2)-C6) > .00001 THEN 2000
4000 C3 = 2*( (PB9-PB11) + (ZN9-ZN11) + (FEZN9-FEZN11) ) + 3*(CU9-CU11)  'mols F
e3+ reqd in stg 3
4010 :
4020 J=42 : K=6 : GOSUB 17000 :LD(42) = LD(6)
4030 L(42) = C3*LD(42)/F3(42)
4040 T(43) = T(11) : SD(43) = SD(11)
4050 L(43) = L(9) + L(42) + T(9) - T(11)
4060 LD(43) = L(43)/( L(9)/LD(9) + L(42)/LD(42) + T(9)/SD(9) - T(11)/SD(11) )
4080 :
4090 G1 = L(9)/LD(9) : G2 = L(42)/LD(42) : G3 = L(43)/LD(43)
4100 PB(43) = (PB(9)*G1 + PB(42)*G2 + (PB9-PB11))/G3
4110 ZN(43) = (ZN(9)*G1 + ZN(42)*G2 + (ZN9-ZN11))/G3
4120 C1(43) = (C1(9)*G1 + C1(42)*G2 + (CU9-CU11))/G3
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4130 C2(43) = (C2(9)*G1 + C2(42)*G2)/G3
4140 F2(43) = (F2(9)*G1 + F2(42)*G2 + (FE9-FE11) + C3)/G3
4150 F3(43) = (F3(9)*G1 + F3(42)*G2 - C3)/G3
4160 NA(43) = (NA(9)*G1 + NA(42)*G2)/G3
4170 H (43) = (H (9)*G1 + H (42)*G2)/G3
4180 CL(43) = (CL(9)*G1 + CL(42)*G2)/G3
4190 W (43) = (W (9)*G1 + W (42)*G2)/G3
4200 :
4210 L(11) = T(11)                : LD(11) = LD(43)
4220 L(10) = L(43) - L(11)        : LD(10) = LD(43)
4230 :
4240 J = 10 : K = 43 : GOSUB 17000
4250 J = 11 : K = 43 : GOSUB 17000
4260 :
4270 ' filter wash ratios
4280 W1 = 2.5
4290 W2 = 2.5
4300 :
4310 L(13) = T(13) * 25/75
4320 PB(14) = 0                   : PB(47) = PB(14)
4330 ZN(14) = 0                   : ZN(47) = ZN(14)
4340 C1(14) = 0                   : C1(47) = C1(14)
4350 C2(14) = 0                   : C2(47) = C2(14)
4360 F2(14) = 0                   : F2(47) = F2(14)
4370 F3(14) = 0                   : F3(47) = F3(14)
4380 NA(14) = 1!                  : NA(47) = NA(14)
4390 H (14) = 0                   : H (47) = H (14)
4400 CL(14) = 0                   : CL(47) = CL(14)
4410 W (14) = 990/(H*2 + OX)      : W (14) = W (14)
4420 :
4430 Y=14 : GOSUB 18000
4440 :
4450 PB(15) = 0                   : PB(46) = PB(15)
4460 ZN(15) = 0                   : ZN(46) = ZN(15)
4470 C1(15) = 0                   : C1(46) = C1(15)
4480 C2(15) = 0                   : C2(46) = C2(15)
4490 F2(15) = 0                   : F2(46) = F2(15)
4500 F3(15) = 0                   : F3(46) = F3(15)
4510 NA(15) = 0                   : NA(46) = NA(15)
4520 H (15) = 0                   : H (46) = H (15)
4530 CL(15) = 0                   : CL(46) = CL(15)
4540 W (15) = 1000/(H*2 + OX) : W (46) = W (15)
4550 :
4560 Y=15 : GOSUB 18000
4570 :
4700 LD(13) = LD(14) + ((1-.7)^W1)*(LD(11)-LD(14))
4710 L(14) = W1*L(13)*LD(14)/LD(13)
4720 L(12) = L(11) + L(14) -L(13)
4730 LD(12) = L(12)/(L(11)/LD(11) + L(14)/LD(14) -L(13)/LD(13))
4740 G1 = L(13)*((1-.7)^W1)/LD(13)
4750 G2 = L(13)/LD(13)
4760 PB(13) = PB(11)*G1/G2
4770 ZN(13) = ZN(11)*G1/G2
4780 C1(13) = C1(11)*G1/G2
4790 C2(13) = C2(11)*G1/G2
4800 F2(13) = F2(11)*G1/G2
4810 F3(13) = F3(11)*G1/G2
4820 NA(13) = NA(11)*G1/G2
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4830 H (13) = (H(11)*G1 + (1-(1-.7)^W1)*G2*H(14))/G2
4840 CL(13) = CL(11)*G1/G2
4850 W (13) = (W(11)*G1 + (1-(1-.7)^W1)*G2*W(14))/G2
4900 :
4910 LD(13) = LD(15) + ((1-.7)^W2)*(LD(13)-LD(15))
4920 L(15) = W2*L(13)*LD(15)/LD(13)
4930 L(12) = L(11) + L(14) + L(15) - L(13)
4940 LD(12) = L(12)/(L(11)/LD(11) + L(14)/LD(14) + L(15)/LD(15) - L(13)/LD(13))
4950 G1 = L(13)*((1-.7)^W2)/LD(13)
4960 G2 = L(13)/LD(13)
4980 PB(13) = PB(13)*G1/G2
4990 ZN(13) = ZN(13)*G1/G2
5000 C1(13) = C1(13)*G1/G2
5010 C2(13) = C2(13)*G1/G2
5020 F2(13) = F2(13)*G1/G2
5030 F3(13) = F3(13)*G1/G2
5040 NA(13) = (NA(13)*G1 + (1-(1-.7)^W2)*G2*NA(15))/G2
5050 H (13) = H(13)*G1/G2
5060 CL(13) = CL(13)*G1/G2
5070 W (13) = (W(13)*G1 + (1-(1-.7)^W2)*G2*W(15))/G2
5080 :
5090 G1=L(14)/LD(14) : G2=L(15)/LD(15) : G3=L(11)/LD(11) : G4=L(13)/LD(13) : G5=
L(12)/LD(12)
5100 PB(12)=(PB(14)*G1 + PB(15)*G2 + PB(11)*G3 - PB(13)*G4)/G5
5110 ZN(12)=(ZN(14)*G1 + ZN(15)*G2 + ZN(11)*G3 - ZN(13)*G4)/G5
5120 C1(12)=(C1(14)*G1 + C1(15)*G2 + C1(11)*G3 - C1(13)*G4)/G5
5130 C2(12)=(C2(14)*G1 + C2(15)*G2 + C2(11)*G3 - C2(13)*G4)/G5
5140 F2(12)=(F2(14)*G1 + F2(15)*G2 + F2(11)*G3 - F2(13)*G4)/G5
5150 F3(12)=(F3(14)*G1 + F3(15)*G2 + F3(11)*G3 - F3(13)*G4)/G5
5160 NA(12)=(NA(14)*G1 + NA(15)*G2 + NA(11)*G3 - NA(13)*G4)/G5
5170 CL(12)=(CL(14)*G1 + CL(15)*G2 + CL(11)*G3 - CL(13)*G4)/G5
5180 H (12)=(H (14)*G1 + H (15)*G2 + H (11)*G3 - H (13)*G4)/G5
5190 W (12)=(W (14)*G1 + W (15)*G2 + W (11)*G3 - W (13)*G4)/G5
5195 :
5200 L(59) = L(10) + L(12)
5210 LD(59) = L(59)/(L(10)/LD(10) + L(12)/LD(12))
5220 G1 = L(10)/LD(10) : G2 = L(12)/LD(12) : G3 = L(59)/LD(59)
5230 PB(59) = (PB(10)*G1 + PB(12)*G2)/G3
5240 ZN(59) = (ZN(10)*G1 + ZN(12)*G2)/G3
5250 C1(59) = (C1(10)*G1 + C1(12)*G2)/G3
5260 C2(59) = (C2(10)*G1 + C2(12)*G2)/G3
5270 F2(59) = (F2(10)*G1 + F2(12)*G2)/G3
5280 F3(59) = (F3(10)*G1 + F3(12)*G2)/G3
5290 NA(59) = (NA(10)*G1 + NA(12)*G2)/G3
5300 CL(59) = (CL(10)*G1 + CL(12)*G2)/G3
5310 H (59) = (H (10)*G1 + H (12)*G2)/G3
5320 W (59) = (W (10)*G1 + W (12)*G2)/G3
5330 :
5350 C7 = LD(6)
5360 L(41) = L(6) + L(42) - L(59)
5370 LD(6) = (L(6)+L(42))/(L(41)/LD(41) + L(59)/LD(59)) : LD(42) = LD(6)
5380 G1 = L(41)/LD(41) : G2 = L(59)/LD(59) : G3 = (L(6)+L(42))/LD(6)
5400 PB(6) = (PB(41)*G1 + PB(59)*G2)/G3
5410 ZN(6) = (ZN(41)*G1 + ZN(59)*G2)/G3
5420 C1(6) = (C1(41)*G1 + C1(59)*G2)/G3
5430 C2(6) = (C2(41)*G1 + C2(59)*G2)/G3
5440 F2(6) = (F2(41)*G1 + F2(59)*G2)/G3
5450 F3(6) = (F3(41)*G1 + F3(59)*G2)/G3
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5460 NA(6) = (NA(41)*G1 + NA(59)*G2)/G3
5470 CL(6) = (CL(41)*G1 + CL(59)*G2)/G3
5480 H (6) = (H (41)*G1 + H (59)*G2)/G3
5490 W (6) = (W (41)*G1 + W (59)*G2)/G3
5500 :
5510 J=42 : K=6 : GOSUB 17000
5515 PRINT "C7=";C7;"          LD(6)=";LD(6)
5520 PRINT
5600 IF ABS(C7 - LD(6)) > .00001 THEN GOTO 2000
5605 L(18) = L(4)  :   LD(18) = LD(4)
5610 J = 18 : K = 4 : GOSUB 17000
5620 'lead required for cementation (twice stoichiometric)
5630 T(17) = (C1(18)*L(18)/(LD(18)*2) + SILVER/(AG*200))*2*PB/1000
5631 SD(17) = 11.35
5635 T(49) = T(17) - (.999*C1(18)*L(18)/(LD(18)*1000))*(PB/2-CU)
5636 SD(49) = T(49)/( T(17)/22.7 +.999*C1(18)*L(18)*CU/(LD(18)*8910) + SILVER*10
/10500000# )
5640 J = 19 : K = 18 : GOSUB 17000
5650 C1(19) = .001*C1(18)
5655 PB(19) = PB(18) + .999*C1(18)/2
5660 Y=19 : GOSUB 18000
5670 L(49) = .25*T(49)
5680 L(47) = 0 : LD(46) = 1!
5690 LD(49) = LD(46) + (1-.7)*(LD(18)-LD(46))
5700 L(46) = W2*L(49)*LD(46)/LD(49)
5710 L(19) = L(18) +  T(17) - T(49) + L(46) - L(49)
5720 '
5730 G1 = L(49)*((1-.7)^W2)/LD(49) : G2 = L(49)/LD(49) : G3 = G1/G2
5740 PB(49) = PB(19)*G3
5750 ZN(49) = ZN(19)*G3
5760 C1(49) = C1(19)*G3
5770 C2(49) = C2(19)*G3
5780 F2(49) = F2(19)*G3
5790 F3(49) = F3(19)*G3
5800 NA(49) = NA(19)*G3
5810 H(49) = H(19)*G3
5820 CL(49) = CL(19)*G3
5830 W(49) = ( W(19)*G1 + (1-(1-.7)^W2)*G2*W(46) )/G2
5840 '
5850 G1 = L(18)/LD(18) : G3 = L(46)/LD(46) : G4 = L(19)/LD(19)
5860 PB(19) = (PB(18)*G1 + PB(46)*G3 - PB(49)*G2)/G4
5870 ZN(19) = (ZN(18)*G1 + ZN(46)*G3 - ZN(49)*G2)/G4
5880 C1(19) = (C1(18)*G1 + C1(46)*G3 - C1(49)*G2)/G4
5890 C2(19) = (C2(18)*G1 + C2(46)*G3 - C2(49)*G2)/G4
5900 F2(19) = (F2(18)*G1 + F2(46)*G3 - F2(49)*G2)/G4
5910 F3(19) = (F3(18)*G1 + F3(46)*G3 - F3(49)*G2)/G4
5920 NA(19) = (NA(18)*G1 + NA(46)*G3 - NA(49)*G2)/G4
5930 H (19) = (H (18)*G1 + H (46)*G3 - H (49)*G2)/G4
5940 CL(19) = (CL(18)*G1 + CL(46)*G3 - CL(49)*G2)/G4
5950 W (19) = (W (18)*G1 + W (46)*G3 - W (49)*G2)/G4
6070 'Lead Chloride crystallisation
6080 :
6090 J = 20 : K=19 : GOSUB 17000
6100 PB(20) = 9/PB              'g mols/L
6110 CL(20) = CL(19) - 2*PB(20)
6120 Y=20 : GOSUB 18000
6130 T(20) = (PB(19) -PB(20)) * (PB + 2*CL)*L(19)/(LD(19)*1000)
6140 T(21) = T(20)
```

```
6150 L(20) = L(19) - T(20)
6200 L(21) = T(20) * 30/70 :W3 = 2.5
6210 J=44 : K=14 : GOSUB 17000
6220 LD(44) = LD(14)
6230 LD(21) = LD(44) + ((1-.7)^W3)*(LD(20) - LD(44))
6240 L(44) = W3*L(21)*LD(44)/LD(21)
6250 L(22) = L(20) + L(44) - L(21)
6254 LD(22) = L(22)/(L(20)/LD(20) + L(44)/LD(44) - L(21)/LD(21))
6260 G1 = L(21)*((1-.7)^W3)/LD(21)
6270 G2 = L(21)/LD(21)
6300 PB(21) = PB(20)*G1/G2
6310 ZN(21) = ZN(20)*G1/G2
6320 C1(21) = C1(20)*G1/G2
6330 C2(21) = C2(20)*G1/G2
6340 F2(21) = F2(20)*G1/G2
6350 F3(21) = F3(20)*G1/G2
6360 NA(21) = NA(20)*G1/G2
6370 H(21) = (H(20)*G1 + (1 - (1-.7)^W3)*G2*H(44) )/G2
6380 CL(21) = CL(20)*G1/G2
6390 W(21) = (W(20)*G1 + (1 - (1-.7)^W3)*G2*W(44) )/G2
6395 '
6400 G1 = L(20)/LD(20) : G3 = L(44)/LD(44) : G4 = L(22)/LD(22)
6410 PB(22) = (PB(20)*G1 + PB(44)*G3 - PB(21)*G2)/G4
6420 ZN(22) = (ZN(20)*G1 + ZN(44)*G3 - ZN(21)*G2)/G4
6430 C1(22) = (C1(20)*G1 + C1(44)*G3 - C1(21)*G2)/G4
6440 C2(22) = (C2(20)*G1 + C2(44)*G3 - C2(21)*G2)/G4
6450 F2(22) = (F2(20)*G1 + F2(44)*G3 - F2(21)*G2)/G4
6460 F3(22) = (F3(20)*G1 + F3(44)*G3 - F3(21)*G2)/G4
6470 NA(22) = (NA(20)*G1 + NA(44)*G3 - NA(21)*G2)/G4
6480 H (22) = (H (20)*G1 + H (44)*G3 - H (21)*G2)/G4
6490 CL(22) = (CL(20)*G1 + CL(44)*G3 - CL(21)*G2)/G4
6500 W (22) = (W (20)*G1 + W (44)*G3 - W (21)*G2)/G4
6510 '
6520 J=24 : K=22 : GOSUB 17000
6530 J=25 : K=24 : GOSUB 17000
6540 L(24) = L(22) : L(25) = L(22)
6550 LD(24) = LD(22) : LD(25) = LD(22)
6560 C15 = .1 * PB(25)*L(25)/LD(25)     'mols/h Pb to organic
6570 C16 = C15 * (PB + CL*2)/1000        'Kg/h PbCl2 to organic
6600 PB(27) = 0
6610 ZN(27) = 40/ZN
6620 C1(27) = 0
6630 C2(27) = 0
6640 F2(27) = 0
6650 F3(27) = 0
6660 NA(27) = 0
6670 H (27) = .43
6680 CL(27) = (PB(27)+ZN(27)+C2(27)+F2(27))*2 + C1(27) + F3(27)*3
6690 W (27) = 950/(H*2 + OX)
6700 '
6710 Y=27 : GOSUB 18000
6720 L(26) = 2.5*L(25)/LD(25)    'Litres/h
6730 LD(26) = .97
6740 L(26) = L(26)*LD(26)
6750 L(27) = L(26)/40           'Ratio of organic to scrub solution = ~ 40
6755 'Calculate composite feed to SX using #29
6760 G1=L(25)/LD(25) : G2=L(27)/LD(27)
6770 L(29)=L(25) + L(27)
```

```
6780 LD(29) = L(29)/(G1+G2)
6790 G3 = L(29)/LD(29)
6800 PB(29) = (PB(25)*G1 + PB(27)*G2)/G3
6810 ZN(29) = (ZN(25)*G1 + ZN(27)*G2)/G3
6820 C1(29) = (C1(25)*G1 + C1(27)*G2)/G3
6830 C2(29) = (C2(25)*G1 + C2(27)*G2)/G3
6840 F2(29) = (F2(25)*G1 + F2(27)*G2)/G3
6850 F3(29) = (F3(25)*G1 + F3(27)*G2)/G3
6860 NA(29) = (NA(25)*G1 + NA(27)*G2)/G3
6870 H (29) = (H (25)*G1 + H (27)*G2)/G3
6880 CL(29) = (CL(25)*G1 + CL(27)*G2)/G3
6890 W (29) = (W (25)*G1 + W (27)*G2)/G3
6900 '
6910 C13 = (ZN(29) - 4/ZN)*G3          'mols/h Zn to organic
6912 C17 = C13*(ZN + CL*2)/1000        'Kg/h ZnCl2 to organic
6915 CL29 = CL(29)*G3 : PB29 = PB(29)*G3 : ZN29 = ZN(29)*G3
6920 L(29) = L(29) - C16 - C17
6924 LD29 = LD(29)                    'initial guess
6925 G4 = L(29)/LD(29)
6927 PB(29) = (PB29 - C15)/G4
6930 ZN(29) = (ZN29 - C13)/G4
6934 CL(29) = (CL29 - 2*C13 - 2*C15)/G4
6938 Y=29 : GOSUB 18000
6940 IF ABS(LD(29) - LD29) > .00001 THEN LD29 = LD(29) : GOTO 6925
6945 C1(29) = C1(29)*G3/G4
6950 C2(29) = C2(29)*G3/G4
6955 F2(29) = F2(29)*G3/G4
6960 F3(29) = F3(29)*G3/G4
6965 NA(29) = NA(29)*G3/G4
6970 H (29) = H (29)*G3/G4
6975 W (29) = W (29)*G3/G4
6990 L(29) = .9*L(29)  :  L(28) =L(29)/9
6995 J=28 : K=29 : GOSUB 17000
7000 LD(28) = LD(29)
7010 IF LD(49) < .5 THEN LD(49) = 1
7030 '
7100 '
7110 ZN(26) = 2/ZN  :  LD(30) = LD(26)
7120 C14 = ZN(25)*L(25)/LD(25) + ZN(27)*L(27)/LD(27) - ZN(29)*(L(28)+L(29))/LD(2
9)  ' mols/h Zn to SX strip
7130 C18 = PB(25)*L(25)/LD(25) - PB(29)*(L(28)+L(29))/LD(29)   ' mols/h Pb to SX
strip
7132 L(30) = L(26) + C14*(ZN+2*CL)/1000 + C18*(PB+2*CL)/1000
7133 PB(30) = (PB(26)*L(26)/LD(26) + C18)/(L(30)/LD(30))
7134 ZN(30) = (ZN(26)*L(26)/LD(26) + C14)/(L(30)/LD(30))
7135 PB(51) = 0 : ZN(51) = 15/ZN : H(51) = .5 :CL(51) = 2*ZN(51) : W(51) = 990/(
H*2 + OX)
7136 Y=51 : GOSUB 18000
7140 T(23) = C18*ZN/1000
7145 SD(23) = 7.18
7150 T(53) = C18*PB/1000
7160 C19 = ZN(30)*L(30)/LD(30) - ZN(26)*L(26)/LD(26) + T(23)*1000/ZN - ZN(27)*L(
27)/LD(27)
7170 T(50) = C19 * ZN/1000
7175 SD(50) = 7.18
7180 T(35) = C19 * 2 * CL/1000
7190 LD(52) = 1 : W(52) = 1000/(H*2+OX)
7200 L(52) = L(26) +T(53) + L(27) +T(50) + T(35) - L(30) - T(23)
```

```
7210 LD(31) = LD(51) : G1 = LD(31)
7220 L(31) = .5*L(30)*LD(31)/LD(30)
7230 L(51) = L(31) - L(52)
7240 LD(31) = L(31)/(L(51)/LD(51) + L(52)/LD(52))
7250 IF ABS(G1 - LD(31)) > .0001 THEN G1 = LD(31) : GOTO 7220
7260 G1 = L(31)/LD(31) : G2 = L(51)/LD(51)
7270 ZN(31) = ZN(51)*G2/G1
7280 CL(31) = CL(51)*G2/G1
7290 H(31)  =  H(51)*G2/G1
7300 W(31)  =  (W(51)*G2 + W(52)*L(52)/LD(52))/G1
7310 L(32) = L(31) + C14*(ZN + 2*CL)/1000
7320 J=32 :K=31 :GOSUB 17000
7330 PB(32) = (PB(31)*G1 + C18)/(L(32)/LD(31))
7340 ZN(32) = (ZN(31)*G1 + C14)/(L(32)/LD(31))
7350 CL(32) = 2*(ZN(32) + PB(32))
7360 Y=32 : GOSUB 18000
7370 L(33) = L(32) + T(23) - T(53)
7380 J=33 : K=32 : GOSUB 17000
7390 PB(33) = 0
7400 ZN(33) = (ZN(32)*L(32)/LD(32) + C18)/(L(33)/LD(32))
7410 CL(33) = 2 * ZN(33)
7420 Y=33 : GOSUB 18000
7430 IF ABS(LD(33) - LD(27)) > .0001 THEN J=27 : K=33 : GOSUB 17000 : LD(27) = L
D(33) : GOTO 6760
7440 L(34) = L(33) - L(27)
7445 LD(34) = LD(33)
7450 J=34 : K=33 : GOSUB 17000
10040 'Solution Oxidation
10050 L(36) = .5*L(29)          '50 % of flow to oxidation
10060 L(37) = L(29) - L(36)
10070 J=36 : K=29 : GOSUB 17000  :  LD(36) = LD(29)
10080 J=37 : K=29 : GOSUB 17000  :  LD(37) = LD(29)
10090 '
10100 ' 4 FeCl2 + O2 + 4 HCl  =  4 FeCl3 + 2 H2O
10110 '
10120 ' 4 FeCl3   +    6 H2O  =  2 Fe2O3 + 12 HCl
10130 ' ----------------------------------------
10140 ' 4 FeCl2 + O2 + 4 H2O  =  2 Fe2O3 + 8 HCl
10150 '
10220 '
10230 SOLFE = FE1 - FE11        'mols/h soluble iron
10240 FELOSS = (F2(13) + F3(13))*L(13)/LD(13) + (F2(21) + F3(21))*L(21)/LD(21) +
 (F2(28) + F3(28))*L(28)/LD(28) + (F2(49) + F3(49))*L(49)/LD(49)
10250 'FELOSS = mols/h of Fe soluble losses
10260 C9 = SOLFE - FELOSS       'mols/h Fe to be removed to maintain Fe balance
10270 IF C9 < 0 THEN C9 = 0
10280 J=39 : K=36 : GOSUB 17000  :  G1 = L(36)/LD(36)
10290 F2(39) = (F2(39)*G1 - 3 * C9)/G1
10300 F3(39) = (F3(39)*G1 + 2 * C9)/G1
10310 C10 = C9 * 3 / 4          'mols/h of O2 required (stoichiometric)
10315 T(38) = C10*15.9997*2/1000
10320 C11 = C9*(FE*2 + 3*OX)/2000 'kg/h Fe2O3 precipitated
10325 T(39) = C11 : T(40) = C11
10330 L(39) = L(36) + C10*2*OX/1000 - C11
10340 Y=39 : GOSUB 18000  :  G2 = L(39)/LD(39)
10341 PB(39) = PB(39)*G1/G2
10342 ZN(39) = ZN(39)*G1/G2
10343 C1(39) = C1(39)*G1/G2
```

```
10344 C2(39) = C2(39)*G1/G2
10345 F2(39) = F2(39)*G1/G2
10346 F3(39) = F3(39)*G1/G2
10347 NA(39) = NA(39)*G1/G2
10348 H (39) = H (39)*G1/G2
10349 CL(39) = CL(39)*G1/G2
10350 W (39) = W (39)*G1/G2
10360 L(40) = L(39) + L(37)
10370 LD(40) = L(40)/(L(39)/LD(39) + L(37)/LD(37))
10380 G1 = L(39)/LD(39) : G2 = L(37)/LD(37) : G3 = L(40)/LD(40)
10390 PB(40) = (PB(39)*G1 + PB(37)*G2)/G3
10400 ZN(40) = (ZN(39)*G1 + ZN(37:*G2)/G3
10410 C1(40) = (C1(39)*G1 + C1(37)*G2)/G3
10420 C2(40) = (C2(39)*G1 + C2(37)*G2)/G3
10430 F2(40) = (F2(39)*G1 + F2(37)*G2)/G3
10440 F3(40) = (F3(39)*G1 + F3(37)*G2)/G3
10450 NA(40) = (NA(39)*G1 + NA(37)*G2)/G3
10460 H (40) = (H (39)*G1 + H (37)*G2)/G3
10470 CL(40) = (CL(39)*G1 + CL(37)*G2)/G3
10480 W (40) = (W (39)*G1 + W (37)*G2)/G3
10490 '
10600 'Chlorination of second stage leachant
10610 '
10620 '2 FeCl2 + Cl2  =  2 FeCl3
10630 '
10640 'assume chlorination to 50 g/L Fe3+ is required ----  ???
10650 '
10660 J=41 : K=40 : GOSUB 17000
10670 G1 = L(40)/LD(40)                                    'initial guess
10680 '
10690 C12 = (50/FE)*G1 - F3(40)*L(40)/LD(40)  'mols/h of Fe to chlorinate
10700 F3(41) = 50/FE
10710 F2(41) = F2(40) - C12
10720 IF F2(41) < 0 THEN F2(41) = 0
10730 CL(41) = (PB(41) + ZN(41) + C2(41) + F2(41))*2 + C1(41) + F3(41)*3
10750 Y = 41 : GOSUB 18000
10760 L(41) = L(40) + C12*CL/1000      'error if F2(41) < 0 in 10720
10770 IF ABS(G1-L(41)/LD(41)) > .00001 THEN G1 = L(41)/LD(41) :GOTO 10690
10775 T(16) = C12*CL/1000 + L(2) - L(8)  'Kg/h chlorine (total)
10780 '
10790 BLEED = L(41) + L(10) +L(12) - (L(6) +L(42))  :PRINT "BLEED  =";BLEED
10795 IF BLEED < 0 AND (BLEED*(-1)) > L(28) THEN L(29) = L(29) + L(28) : L(28) =
0 : IF ABS(C14-BLEED) < .001 THEN 7890 ELSE C14=BLEED : GOTO 10050
10800 IF ABS(C14 - BLEED) > .01 THEN L(28) = L(28) + BLEED : L(29) = L(29) - BLE
ED : C14 = BLEED : GOTO 10050
10890 J = 41 : GOSUB 20000
10900 CLS : LOCATE 5,20 :PRINT "ITERATE BALANCE AGAIN (Y/N) ?";
10910 INPUT A$ :IF A$ = "N" THEN 12000 ELSE 10920
10920 IF A$ <> "Y" THEN 10900
10930 J=6  : K=41 : GOSUB 17000
10940 J=42 : K=41 : GOSUB 17000
10950 GOTO 2000
12000 GOSUB 21000
12010 INPUT B$ : IF B$ = "" THEN 12010
12020 CLS : LOCATE 5,10 : PRINT "DO YOU WISH TO VIEW RESULTS (Y/N) ";:INPUT B$
12030 IF B$ = "Y" THEN GOTO 12100 ELSE IF B$ = "N" THEN GOTO 12300
12040 GOTO 12020
12100 FOR J=1 TO 50 : GOSUB 20000
```

```
12110 IF A$ = "Q" OR A$ = "q" THEN 12300
12120 NEXT J
12200 '
12300 CLS : LOCATE 10,15:PRINT "IS PRINT-OUT REQUIRED (Y/N) ?";:INPUT A$
12310 IF A$ = "N" THEN 14000
12320 IF A$ = "Y" THEN GOTO 26000
12330 GOTO 12300
14000 END
15000 PRINT ERR,ERL
15010 RESUME
17000 PB(J) = PB(K)
17010 ZN(J) = ZN(K)
17020 C1(J) = C1(K)
17030 C2(J) = C2(K)
17040 F2(J) = F2(K)
17050 F3(J) = F3(K)
17060 NA(J) = NA(K)
17070 H (J) = H (K)
17080 CL(J) = CL(K)
17090 W (J) = W (K)
17100 RETURN
17200 :
18000 'Routine to calculate solution densitv
18010 :
18020 LD(Y) = PB(Y)*PB + ZN(Y)*ZN + (C1(Y)+C2(Y))*CU + (F2(Y)+F3(Y))*FE
18030 LD(Y) = LD(Y) + ( C1(Y) + 2*(PB(Y)+ZN(Y)+C2(Y)+F2(Y)) + 3*F3(Y) ) * CL
18040 LD(Y) = LD(Y) + W(Y)*(H*2 + OX)
18050 LD(Y) = LD(Y) + NA(Y)*(NA+CL) + H(Y)*(H+CL)
18060 LD(Y) = LD(Y)/1000
18100 RETURN
19000 :
20000 'PRINT SUBROUTINE
20010 :
20020 G = L(J)/LD(J): R1$="####.####     ####.####     ####.####":Z = 0
20030 CLS:LOCATE 1,5:PRINT"STREAM NUMBER";J SPC( 3)"G-MOLS/L        MOLS/H
   G/L"
20040 PRINT"-------------------------------------------------------------------------
-----------"
20050 R$="LEAD             "+R1$ : LOCATE 3.5 :PRINT USING R$; PB(J); PB(J)*G; P
B(J)*PB : Z = Z + PB(J) * PB
20054 LOCATE 3,65 : PRINT "Solids, kg/h"
20055 LOCATE 4.63 : PRINT USING "   ###.###";T(J)
20060 R$="ZINC             "+R1$ : LOCATE 5.5 :PRINT USING R$; ZN(J), ZN(J)*G, Z
N(J)*ZN : Z = Z + ZN(J) * ZN
20070 R$="CUPROUS CU       "+R1$ : LOCATE 7,5 :PRINT USING R$; C1(J), C1(J)*G, C
1(J)*CU : Z = Z + C1(J) * CU
20072 R$="CUPRIC CU        "+R1$ : LOCATE 9,5 :PRINT USING R$; C2(J), C2(J)*G, C
2(J)*CU : Z = Z + C2(J) * CU
20074 LOCATE 7,65 :PRINT "Solids s.g."
20075 LOCATE 8,63 : PRINT USING "   ###.###";SD(J)
20080 R$="FERROUS FE       "+R1$ : LOCATE 11.5 :PRINT USING R$; F2(J), F2(J)*G,
F2(J)*FE : Z = Z + F2(J) * FE
20090 R$="FERRIC FE        "+R1$ : LOCATE 13.5 :PRINT USING R$; F3(J), F3(J)*G,
F3(J)*FE : Z = Z + F3(J) * FE
20094 LOCATE 11,65 :PRINT "Liquids, kg/h"
20095 LOCATE 12,63 : PRINT USING "   ###.###";L(J)
20100 R$="NaCl             "+R1$ : LOCATE 15,5 :PRINT USING R$; NA(J), NA(J)*G,
NA(J)*(NA + CL) : Z = Z + NA(J) * (NA + CL)
```

```
20110 R$="HCl                 "+R1$ : LOCATE 17,5 :PRINT USING R$; H(J), H(J)*G, H(
J)*(H + CL) : Z = Z + H(J) * (H + CL)
20114 LOCATE 15.65 :PRINT "Liquids s.g."
20115 LOCATE 16,63 : PRINT USING "    ###.###";LD(J)
20120 R$="CHLORIDE            "+R1$ : LOCATE 19,5 :PRINT USING R$; CL(J), CL(J)*G,
CL(J)*CL : Z = Z + CL(J) * CL
20130 R$="WATER               "+R1$ : LOCATE 21.5 :PRINT USING R$; W(J), W(J)*G, W(
J)*(H*2 + OX); Z = Z + W(J) * (H*2 + OX)
20134 LOCATE 19.65 :PRINT "Liquids, L/h"
20135 LOCATE 20,63 : PRINT USING "    ###.###";L(J)/LD(J) : LOCATE 22.1
20140 PRINT"--------------------------------------------------------------------
-----------"
20150 PRINT SPC(49) USING "####.##";Z
20155 FOR K=3 TO 21 :LOCATE K.61:PRINT"*":NEXT K
20160 A$ = INKEY$ : IF A$ = "" THEN 20160
20200 RETURN
21000 'Material balance checks
21100 '
21110 FOR J=1 TO 23           ' 23 = number of checks
21120 N=1 : K=0
21130 READ C(N) : K = K+1
21140 IF C(N) <> 0 THEN N = N+1 : GOTO 21130
21150 PRINT
21160 PRINT "CHECK NUMBER ";J;"   STREAMS : ";
21170 S=0
21180 FOR I=1 TO K-1
21190 S = S + SGN(C(I)) * (T(ABS(C(I))) + L(ABS(C(I))))
21200 PRINT C(I);
21210 NEXT I
21220 IF ABS(S) < .001 THEN S=0
21230 PRINT
21240 IF S <> 0 THEN PRINT "SOLIDS & LIQUIDS : ";S
21250 NEXT J
21300 RETURN
25000 'Stream numbers for material balance checks
25100 '
25110 DATA 1,2,+48,-3,0
25120 DATA 4,5,-3,0
25130 DATA 5,6,-7,0
25140 DATA 8,9,-7,0
25150 DATA 42,9,-43,0
25160 DATA 10,11,-43,0
25170 DATA 11,14,15,-12,-13,0
25180 DATA 10,12,41,-6,-42,0
25190 DATA 1,2,-8,41,14,15,+48,-13,-4,0
25200 DATA 17,18,46,47,-19,-49,0
25210 DATA 19,-20,0
25220 DATA 19,44,45,-21,-24,0
25230 DATA 25,26,27,-28,-29,-30,0
25240 DATA 30,31,-32,-26,0
25250 DATA 31,35,50,-34,-52,0
25260 DATA 36,37,-29,0
25270 DATA 36,38,-39,0
25280 DATA 37,39,-40,0
25290 DATA 23,32,-33,-53,0
25300 DATA 33,-27,-34,0
25310 DATA 8,16,40,-2,-41,0
25320 DATA 51,52,-31,0
```

```
25330 DATA 1,14,15,16,17,23,38,44,45,46,47,48,52,-13,-21,-28,-35,-49,-50,-53,0
26000 '
26090 S1$ = "          " : S2$ = "          " : S3$ = "        "
26099 '
26100 LPRINT CHR$(12)
26105 LPRINT CHR$(27);"!";CHR$(24);
26110 J=1 : K=5
26120 LPRINT "          STREAM NUMBER :     ";
26130 FOR I=J TO K
26140 I$ = RIGHT$("  "+STR$(I),2)
26150 LPRINT I$ SPC(10);
26160 NEXT I
26200 LPRINT "          ----------------------------------------------------------
-------------"
26210                    LPRINT "          Kg/h Solids       ";
26220 FOR I=J TO K
26230 LPRINT USING "###.#"; T(I);:LPRINT S1$ ;
26240 NEXT I
26250 LPRINT CHR$(13);:LPRINT "          Solids Density    ";
26260 FOR I=J TO K
26270 LPRINT USING "###.#";SD(I) ;: LPRINT S1$ ;
26280 NEXT I
26300 LPRINT CHR$(13);:LPRINT "          Kg/h Liquids      ";
26310 FOR I=J TO K
26320 LPRINT USING "###.#"; L(I) ;: LPRINT S1$ ;
26330 NEXT I
26340 LPRINT CHR$(13);:LPRINT "          Liquids Density   ";
26350 FOR I=J TO K
26360 LPRINT USING "###.#";LD(I) ;: LPRINT S1$ ;
26370 NEXT I
26400 LPRINT CHR$(13);:LPRINT "          Slurry Flow, L/h ";
26410 FOR I=J TO K
26420 IF SD(I) < .5 THEN SD(I) = 1
26430 IF LD(I) < .5 THEN LD(I) = 1
26440 LPRINT USING "###.#"; (T(I)/SD(I) + L(I)/LD(I)) ;: LPRINT S1$ ;
26450 NEXT I
26500 LPRINT "          ----------------------------------------------------------
-------------"
26510 LPRINT "          LEAD"
26520 LPRINT "               g-mols/L      ";
26530 FOR I=J TO K
26540 LPRINT USING "#.###";PB(I) ;
26545 IF I < K THEN LPRINT S2$ ;
26550 NEXT I
26560 LPRINT "               mols/h        ";
26570 FOR I=J TO K
26580 LPRINT USING "###.#";PB(I)*L(I)/LD(I) ;
26585 IF I < K THEN LPRINT S2$ ;
26590 NEXT I
26600 LPRINT "               g/L           ";
26610 FOR I=J TO K
26620 LPRINT USING "###.#";PB(I)*PB ;
26625 IF I < K THEN LPRINT S2$ ;
26630 NEXT I
26700 LPRINT
26710 LPRINT "          ZINC"
26720 LPRINT "               g-mols/L      ";
26730 FOR I=J TO K
```

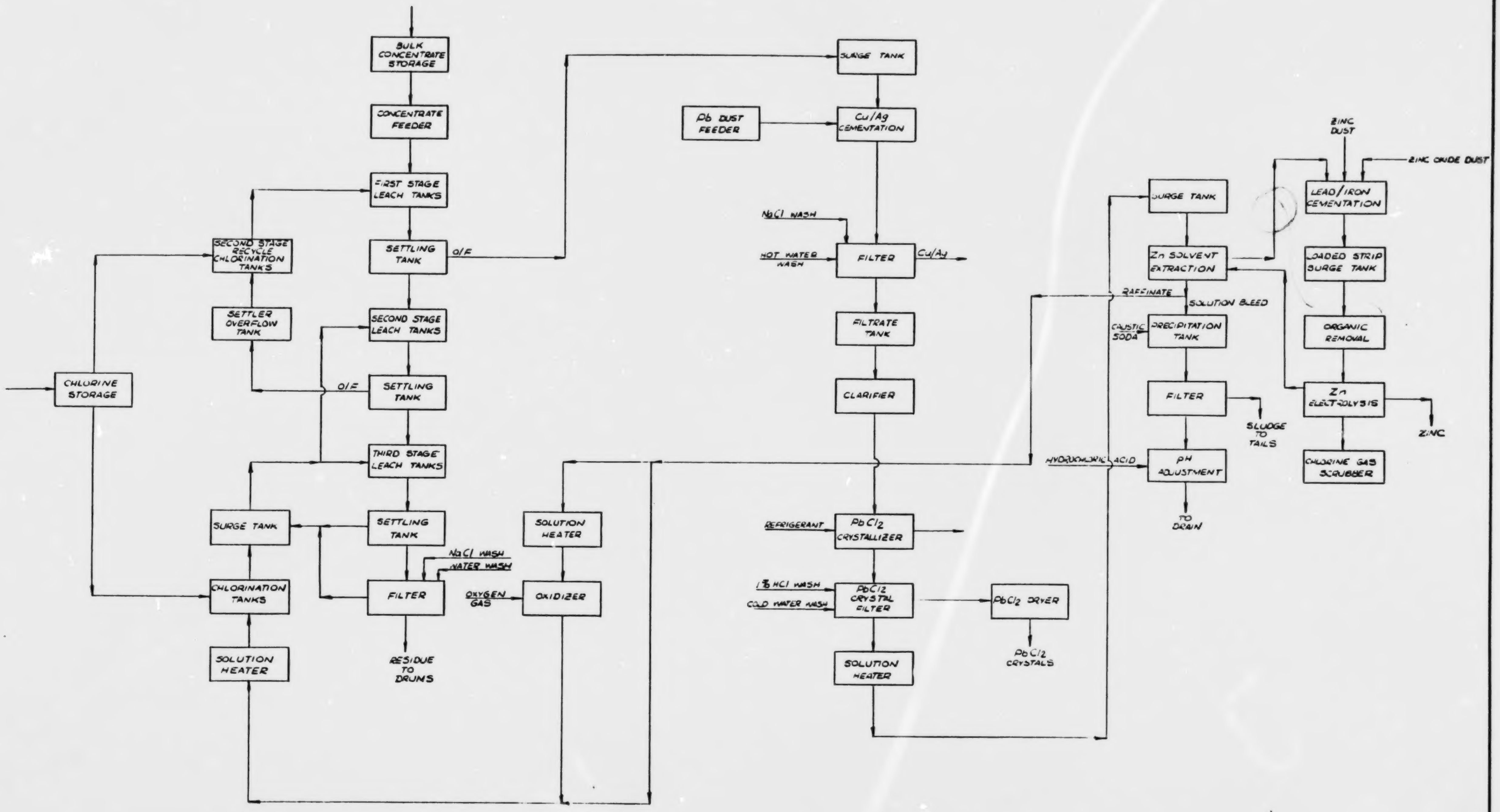
```
26740 LPRINT USING "#.###";ZN(I) ;
26745 IF I < K THEN LPRINT S2$ ;
26750 NEXT I
26760 LPRINT "                  mols/h          ";
26770 FOR I=J TO K
26780 LPRINT USING "###.#";ZN(I)*L(I)/LD(I) ;
26785 IF I < K THEN LPRINT S2$ ;
26790 NEXT I
26800 LPRINT "                  g/L             ";
26810 FOR I=J TO K
26820 LPRINT USING "###.#";ZN(I)*ZN ;
26825 IF I < K THEN LPRINT S2$ ;
26830 NEXT I
26900 LPRINT
26910 LPRINT "             COPPER"
26920 LPRINT "                  g-mols/L       ";
26930 FOR I=J TO K
26940 LPRINT USING "#.###";C1(I) ;
26945 IF I < K THEN LPRINT S2$ ;
26950 NEXT I
26960 LPRINT "                  mols/h          ";
26970 FOR I=J TO K
26980 LPRINT USING "###.#";C1(I)*L(I)/LD(I) ;
26985 IF I < K THEN LPRINT S2$ ;
26990 NEXT I
27000 LPRINT "                  g/L             ";
27010 FOR I=J TO K
27020 LPRINT USING "###.#";C1(I)*CU ;
27025 IF I < K THEN LPRINT S2$ ;
27030 NEXT I
27100 LPRINT
27110 LPRINT "             FERROUS FE"
27120 LPRINT "                  g-mols/L       ";
27130 FOR I=J TO K
27140 LPRINT USING "#.###";F2(I) ;
27145 IF I < K THEN LPRINT S2$ ;
27150 NEXT I
27160 LPRINT "                  mols/h          ";
27170 FOR I=J TO K
27180 LPRINT USING "###.#";F2(I)*L(I)/LD(I) ;
27185 IF I < K THEN LPRINT S2$ ;
27190 NEXT I
27200 LPRINT "                  g/L             ";
27210 FOR I=J TO K
27220 LPRINT USING "###.#";F2(I)*FE ;
27225 IF I < K THEN LPRINT S2$ ;
27230 NEXT I
27300 LPRINT
27310 LPRINT "             FERRIC FE"
27320 LPRINT "                  g-mols/L       ";
27330 FOR I=J TO K
27340 LPRINT USING "#.###";F3(I) ;
27345 IF I < K THEN LPRINT S2$ ;
27350 NEXT I
27360 LPRINT "                  mols/h          ";
27370 FOR I=J TO K
27380 LPRINT USING "###.#";F3(I)*L(I)/LD(I) ;
27385 IF I < K THEN LPRINT S2$ ;
```

```
27390 NEXT I
27400 LPRINT "            g/L          ";
27410 FOR I=J TO K
27420 LPRINT USING "###.#";F3(I)*FE ;
27425 IF I < K THEN LPRINT S2$ ;
27430 NEXT I
27500 LPRINT
27510 LPRINT "        NaCl     "
27520 LPRINT "            g-mols/L     ";
27530 FOR I=J TO K
27540 LPRINT USING "#.###";NA(I) ;
27545 IF I < K THEN LPRINT S2$ ;
27550 NEXT I
27560 LPRINT "            mols/h       ";
27570 FOR I=J TO K
27580 LPRINT USING "###.#";NA(I)*L(I)/LD(I) ;
27585 IF I < K THEN LPRINT S2$ ;
27590 NEXT I
27600 LPRINT "            g/L          ";
27610 FOR I=J TO K
27620 LPRINT USING "###.#";NA(I)*(NA+CL) ;
27625 IF I < K THEN LPRINT S2$ ;
27630 NEXT I
27700 LPRINT
27710 LPRINT "        HCl      "
27720 LPRINT "            g-mols/L     ";
27730 FOR I=J TO K
27740 LPRINT USING "#.###";H(I) ;
27745 IF I < K THEN LPRINT S2$ ;
27750 NEXT I
27760 LPRINT "            mols/h       ";
27770 FOR I=J TO K
27780 LPRINT USING "###.#";H(I)*L(I)/LD(I) ;
27785 IF I < K THEN LPRINT S2$ ;
27790 NEXT I
27800 LPRINT "            g/L          ";
27810 FOR I=J TO K
27820 LPRINT USING "###.#";H(I)*(H+CL) ;
27825 IF I < K THEN LPRINT S2$ ;
27830 NEXT I
27900 LPRINT
27910 LPRINT "        CHLORIDE"
27920 LPRINT "            g-mols/L     ";
27930 FOR I=J TO K
27940 LPRINT USING "#.###";CL(I) ;
27945 IF I < K THEN LPRINT S2$ ;
27950 NEXT I
27960 LPRINT "            mols/h       ";
27970 FOR I=J TO K
27980 LPRINT USING "###.#";CL(I)*L(I)/LD(I) ;
27985 IF I < K THEN LPRINT S2$ ;
27990 NEXT I
27991 LPRINT "            g/L          ";
27992 FOR I=J TO K
27993 LPRINT USING "###.#";CL(I)*(CL) ;
27994 IF I < K THEN LPRINT S2$ ;
27995 NEXT I
28000 LPRINT
```

```
28010 LPRINT "         WATER    "
28020 LPRINT "              g-mols/L     ";
28030 FOR I=J TO K
28040 LPRINT USING "##.###";W(I) ;
28045 IF I < K THEN LPRINT S3$ ;
28050 NEXT I
28060 LPRINT "              mols/h       ";
28070 FOR I=J TO K
28080 LPRINT USING "####.#";W(I)*L(I)/LD(I) ;
28085 IF I < K THEN LPRINT S3$ ;
28090 NEXT I
28100 LPRINT "              g/L          ";
28110 FOR I=J TO K
28120 LPRINT USING "####.#";W(I)*(H*2+OX) ;
28125 IF I < K THEN LPRINT S3$ ;
28130 NEXT I
28140 LPRINT "         ------------------------------------------------------------
--------------"
28150 LPRINT CHR$(12)
28160 '
29000 J = J+5 : K = K+5
29100 IF J > 52 THEN 550
29110 GOTO 26120
```

APPENDIX 4C

DRAWINGS


BULK CONCENTRATE STORAGE
CONCENTRATE FEEDER
FIRST STAGE LEACH TANKS
SETTLING TANK
O/F
SECOND STAGE RECYCLE CHLORINATION TANKS
SETTLER OVERFLOW TANK
SECOND STAGE LEACH TANKS
SETTLING TANK
O/F
CHLORINE STORAGE
THIRD STAGE LEACH TANKS
SURGE TANK
SETTLING TANK
NaCl WASH
WATER WASH
FILTER
CHLORINATION TANKS
SOLUTION HEATER
RESIDUE TO DRUMS
SOLUTION HEATER
OXYGEN GAS
OXIDIZER
SURGE TANK
Pb DUST FEEDER
Cu/Ag CEMENTATION
NaCl WASH
HOT WATER WASH
FILTER
Cu/Ag
FILTRATE TANK
CLARIFIER
REFRIGERANT
PbCl2 CRYSTALLIZER
1% HCl WASH
COLD WATER WASH
PbCl2 CRYSTAL FILTER
PbCl2 DRYER
PbCl2 CRYSTALS
SOLUTION HEATER
SURGE TANK
Zn SOLVENT EXTRACTION
RAFFINATE
SOLUTION BLEED
CAUSTIC SODA
PRECIPITATION TANK
FILTER
SLUDGE TO TAILS
HYDROCHLORIC ACID
pH ADJUSTMENT
TO DRAIN
ZINC DUST
ZINC OXIDE DUST
LEAD/IRON CEMENTATION
LOADED STRIP SURGE TANK
ORGANIC REMOVAL
Zn ELECTROLYSIS
ZINC
CHLORINE GAS SCRUBBER

No.	REVISIONS	DATE	BY	CHD	APPD
0	FOR ISSUE	85.04.22	H.R.		

ENGINEERING REVIEW

AUTHORIZED FOR RELEASE

PROCESS ENGINEER

PROJECT ENGINEER 85.04.12

CUSTOMER APPROVAL

DRAWING STATUS

DSS – CANMET

FERRIC CHLORIDE LEACH

PILOT PLANT

PROCESS BLOCK DIAGRAM

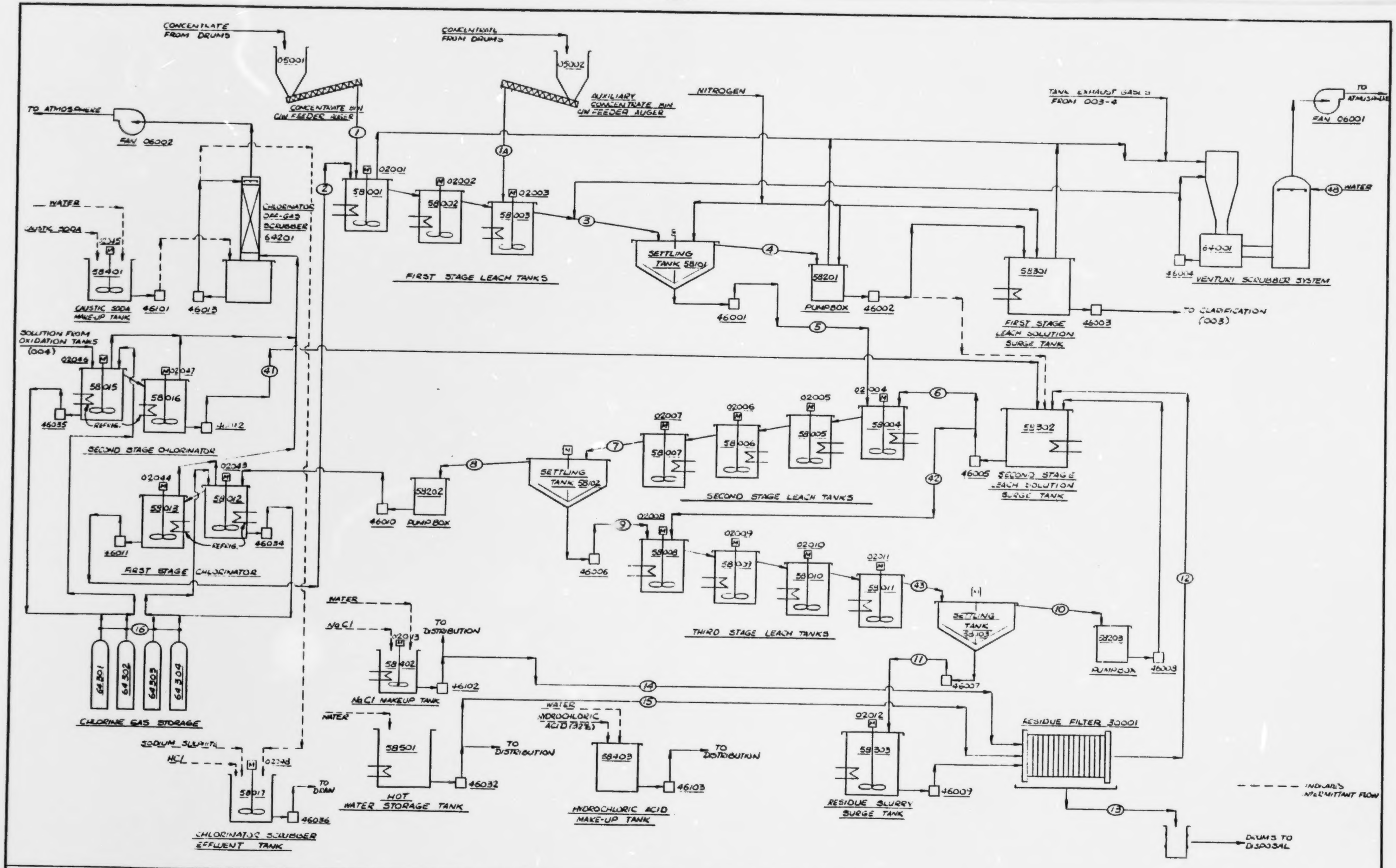
STEARNS CATALYTIC

6221

080-001

H.R. 85.04.22

0


CONCENTRATE FROM DRUMS
05001
CONCENTRATE BIN C/W FEEDER AUGER
CONCENTRATE FROM DRUMS
05002
AUXILIARY CONCENTRATE BIN C/W FEEDER AUGER
NITROGEN
TANK EXHAUST GASES FROM 003-4
TO ATMOSPHERE
FAN 06001
TO ATMOSPHERE
FAN 06002
1
1A
2
M 02001
58001
M 02002
58002
M 02003
58003
3
FIRST STAGE LEACH TANKS
WATER
CAUSTIC SODA
02045
58401
CAUSTIC SODA MAKE-UP TANK
46101
46013
CHLORINATOR OFF-GAS SCRUBBER 64201
SETTLING TANK 58101
4
58201
PUMPBOX
46002
46001
5
58301
FIRST STAGE LEACH SOLUTION SURGE TANK
46003
TO CLARIFICATION (003)
64001
46004
VENTURI SCRUBBER SYSTEM
48 WATER
SOLUTION FROM OXIDATION TANKS (004)
02046
58015
M 02047
58016
41
46035
REFRIG.
46012
SECOND STAGE CHLORINATOR
02004
58004
02005
58005
02006
58006
02007
58007
6
7
SETTLING TANK 58102
8
58202
PUMP BOX
46010
SECOND STAGE LEACH TANKS
58302
46005
SECOND STAGE LEACH SOLUTION SURGE TANK
42
02044
58013
02043
58012
46011
REFRIG.
46034
FIRST STAGE CHLORINATOR
9
02008
58008
46006
02009
58009
02010
58010
02011
58011
43
SETTLING TANK 58103
10
58203
PUMPBOX
46008
12
THIRD STAGE LEACH TANKS
16
64301
64302
64303
64304
CHLORINE GAS STORAGE
WATER
NaCl
02013
58402
TO DISTRIBUTION
46102
NaCl MAKEUP TANK
14
15
11
46007
WATER
58501
TO DISTRIBUTION
46032
HOT WATER STORAGE TANK
WATER
HYDROCHLORIC ACID (32%)
58403
TO DISTRIBUTION
46103
HYDROCHLORIC ACID MAKE-UP TANK
02012
58303
46009
RESIDUE SLURRY SURGE TANK
RESIDUE FILTER 30001
13
DRUMS TO DISPOSAL
SODIUM SULPHITE
HCL
02048
58017
TO DRAIN
46036
CHLORINATOR SCRUBBER EFFLUENT TANK
INDICATES INTERMITTANT FLOW

NO.	REVISIONS	DATE	BY	CHD	APP'D
0	FOR ISSUE	85 04 22	HC		

ENGINEERING REVIEW

DATE	APP'D BY
CONTROL SYSTEMS	
ELECTRICAL	
EQUIPMENT	
PIPING ENG.	
PIPING DES.	
PROCESS ENG.	

AUTHORIZED FOR RELEASE

	APP'D BY	DATE
PROCESS ENGINEER		
PROJECT ENGINEER		85 04 22

CUSTOMER APPROVAL

DRAWING STATUS

DSS – CANMET

PROCESS FLOWSHEET

LEACH AREA

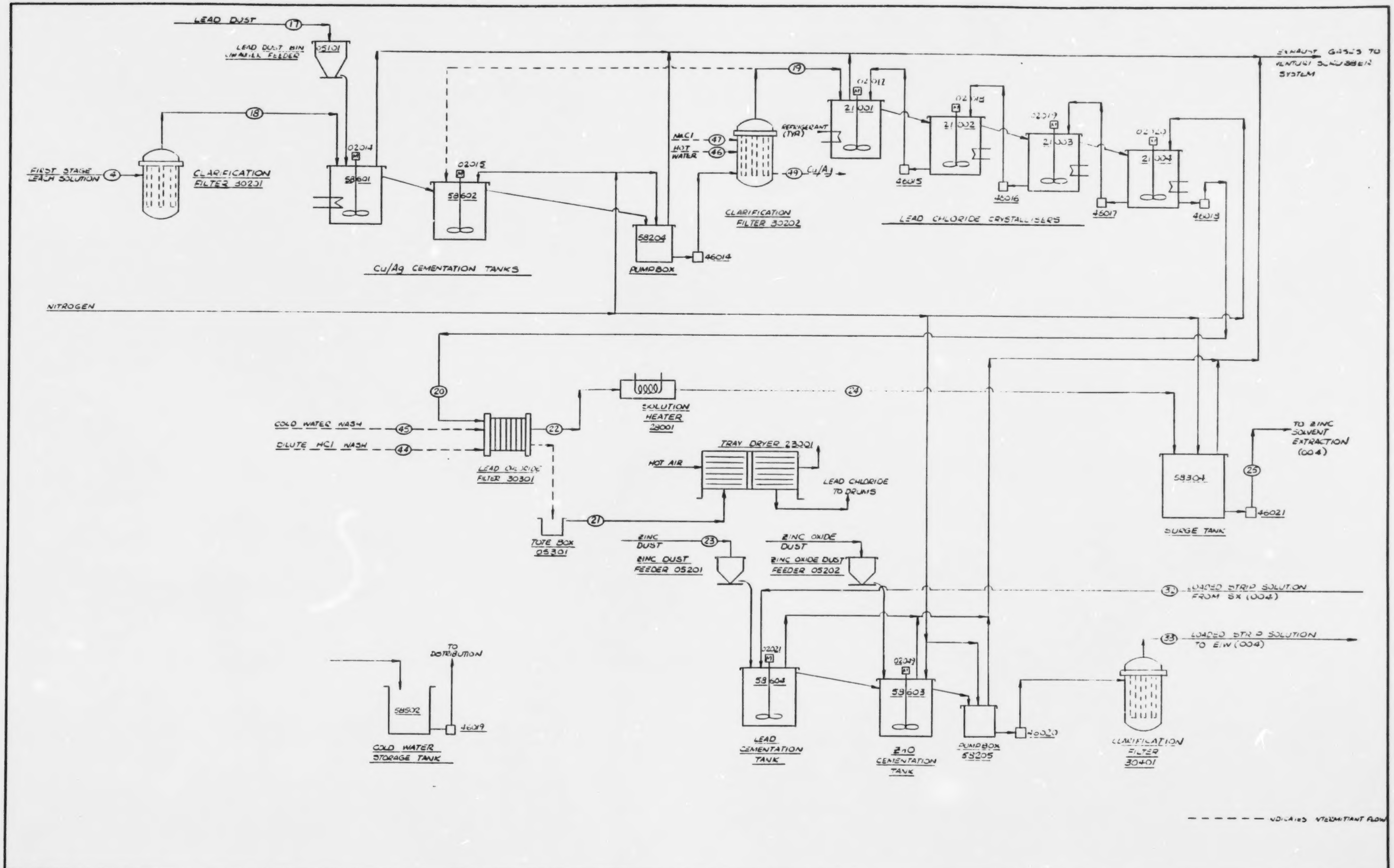
STEARNS CATALYTIC

PROJECT NO. 6221

080-002

HK 85 02 28

REVISION 0


LEAD DUST
17
LEAD DUST BIN W/RATE FEEDER 05101
18
FIRST STAGE LEACH SOLUTION
4
CLARIFICATION FILTER 30201
02014
58601
02015
58602
58204
PUMPBOX
46014
Cu/Ag CEMENTATION TANKS
NaCl
47
HOT WATER
46
REFRIGERANT (TYP)
49
Cu/Ag
CLARIFICATION FILTER 30202
19
02011
21001
02012
21002
02019
21003
02020
21004
46015
46016
46017
46018
LEAD CHLORIDE CRYSTALLISERS
EXHAUST GASES TO VENTURI SCRUBBER SYSTEM
NITROGEN
20
SOLUTION HEATER 28001
24
COLD WATER WASH
45
DILUTE HCl WASH
44
22
LEAD CHLORIDE FILTER 30301
TRAY DRYER 23001
HOT AIR
LEAD CHLORIDE TO DRUMS
21
TOTE BOX 05301
ZINC DUST
23
ZINC DUST FEEDER 05201
ZINC OXIDE DUST
ZINC OXIDE DUST FEEDER 05202
58304
46021
SURGE TANK
25
TO ZINC SOLVENT EXTRACTION (004)
32
LOADED STRIP SOLUTION FROM SX (004)
33
LOADED STRIP SOLUTION TO E.W (004)
TO DISTRIBUTION
58502
46019
COLD WATER STORAGE TANK
02021
58604
LEAD CEMENTATION TANK
02022
58603
ZnO CEMENTATION TANK
PUMPBOX 58205
46020
CLARIFICATION FILTER 30401
INDICATES INTERMITTANT FLOW

No.	REVISIONS	DATE	BY	CHD	APPD
0	FOR ISSUE	85.04 22	HR		

ENGINEERING REVIEW

CONTROL SYSTEMS
ELECTRICAL
EQUIPMENT
PIPING ENG
PIPING DES
PROCESS ENG

AUTHORIZED FOR RELEASE

PROCESS ENGINEER
PROJECT ENGINEER 85.04 22

CUSTOMER APPROVAL

DRAWING STATUS

DSS - CANMET

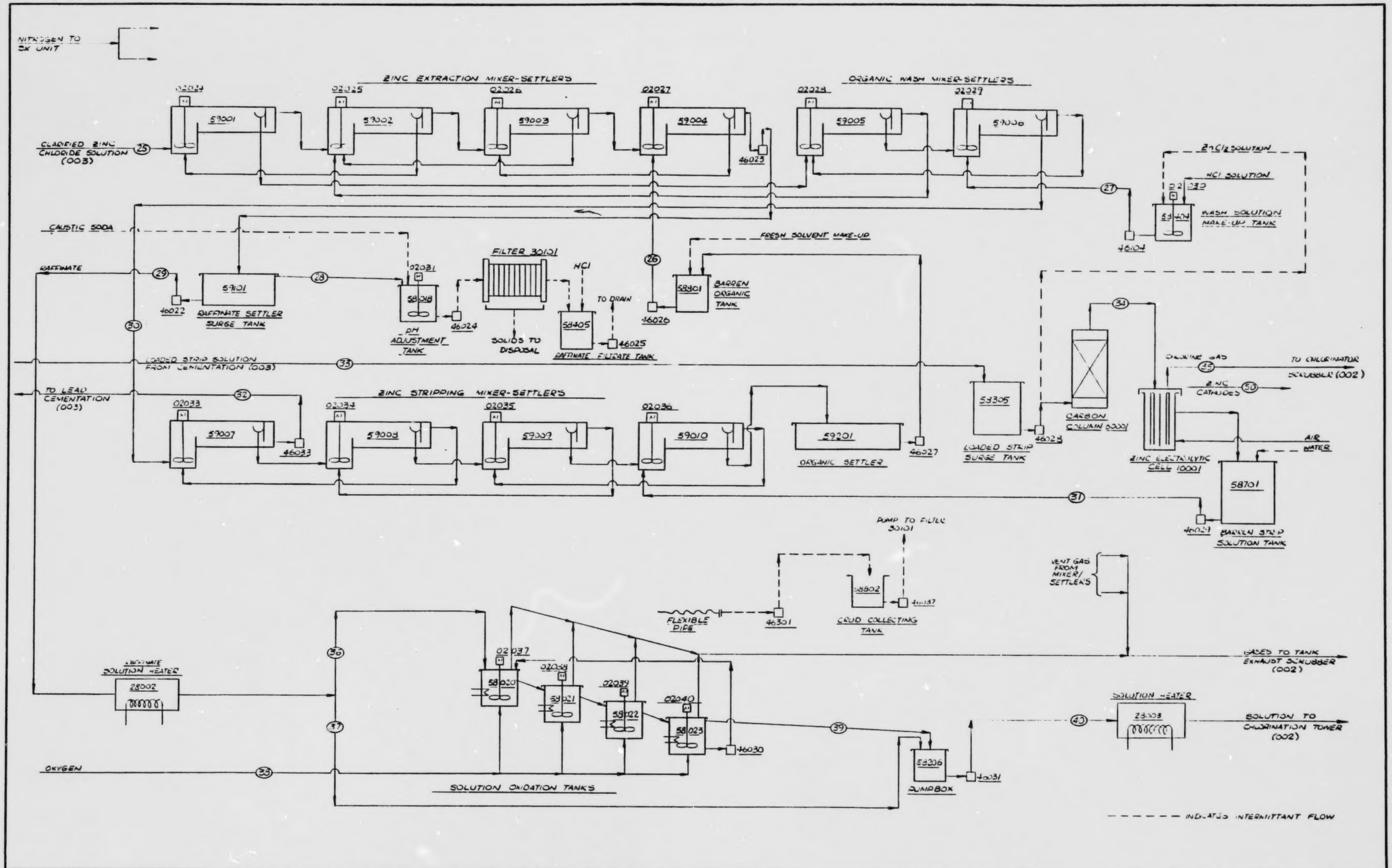
PROCESS FLOWSHEET

CEMENTATION & $PbCl_2$ CRYSTALLISATION

6221

080-003

CATALYTIC


NITROGEN TO SX UNIT
ZINC EXTRACTION MIXER-SETTLERS
ORGANIC WASH MIXER-SETTLERS
02024
02025
02026
02027
02028
02029
59001
59002
59003
59004
59005
59006
CLARIFIED ZINC CHLORIDE SOLUTION (003)
25
46023
ZnCl2 SOLUTION
HCl SOLUTION
02 030
58404
WASH SOLUTION MAKE-UP TANK
27
46104
CAUSTIC SODA
RAFFINATE
29
59101
46022
RAFFINATE SETTLER SURGE TANK
28
02031
58018
46024
pH ADJUSTMENT TANK
FILTER 30101
SOLIDS TO DISPOSAL
HCl
58405
TO DRAIN
46025
RAFFINATE FILTRATE TANK
26
46026
FRESH SOLVENT MAKE-UP
58801
BARREN ORGANIC TANK
30
LOADED STRIP SOLUTION FROM CEMENTATION (003)
33
34
CHLORINE GAS
35
TO CHLORINATOR SCRUBBER (002)
ZINC CATHODES
50
TO LEAD CEMENTATION (003)
32
ZINC STRIPPING MIXER-SETTLERS
02033
02034
02035
02036
59007
59008
59009
59010
46033
59201
ORGANIC SETTLER
46027
58305
LOADED STRIP SURGE TANK
46028
CARBON COLUMN 60001
ZINC ELECTROLYTIC CELL 10001
AIR
WATER
58701
31
46029
BARREN STRIP SOLUTION TANK
PUMP TO FILTER 30101
58802
46037
CRUD COLLECTING TANK
FLEXIBLE PIPE
46301
VENT GAS FROM MIXER/ SETTLERS
36
02037
02038
02039
02040
58020
58021
58022
58023
RAFFINATE SOLUTION HEATER
28002
37
46030
39
GASES TO TANK EXHAUST SCRUBBER (002)
SOLUTION HEATER
28003
40
SOLUTION TO CHLORINATION TOWER (002)
OXYGEN
38
SOLUTION OXIDATION TANKS
58206
PUMPBOX
46031
INDICATES INTERMITTANT FLOW

REV	REVISIONS	DATE	BY	CHD	APP'D
0	FOR ISSUE	85.04 .22	H.R.		

ENGINEERING REVIEW

DATE	APP'D BY
CONTROL SYSTEMS	
ELECTRICAL	
EQUIPMENT	
PIPING ENG	
PIPING DES	
PROCESS ENG	

AUTHORIZED FOR RELEASE

	APP'D BY	DATE
PROCESS ENGINEER		
PROJECT ENGINEER		85.04 .22

CUSTOMER APPROVAL

BY DATE

DRAWING STATUS

DSS – CANMET

PROCESS FLOWSHEET

ZINC SOLVENT EXTRACTION

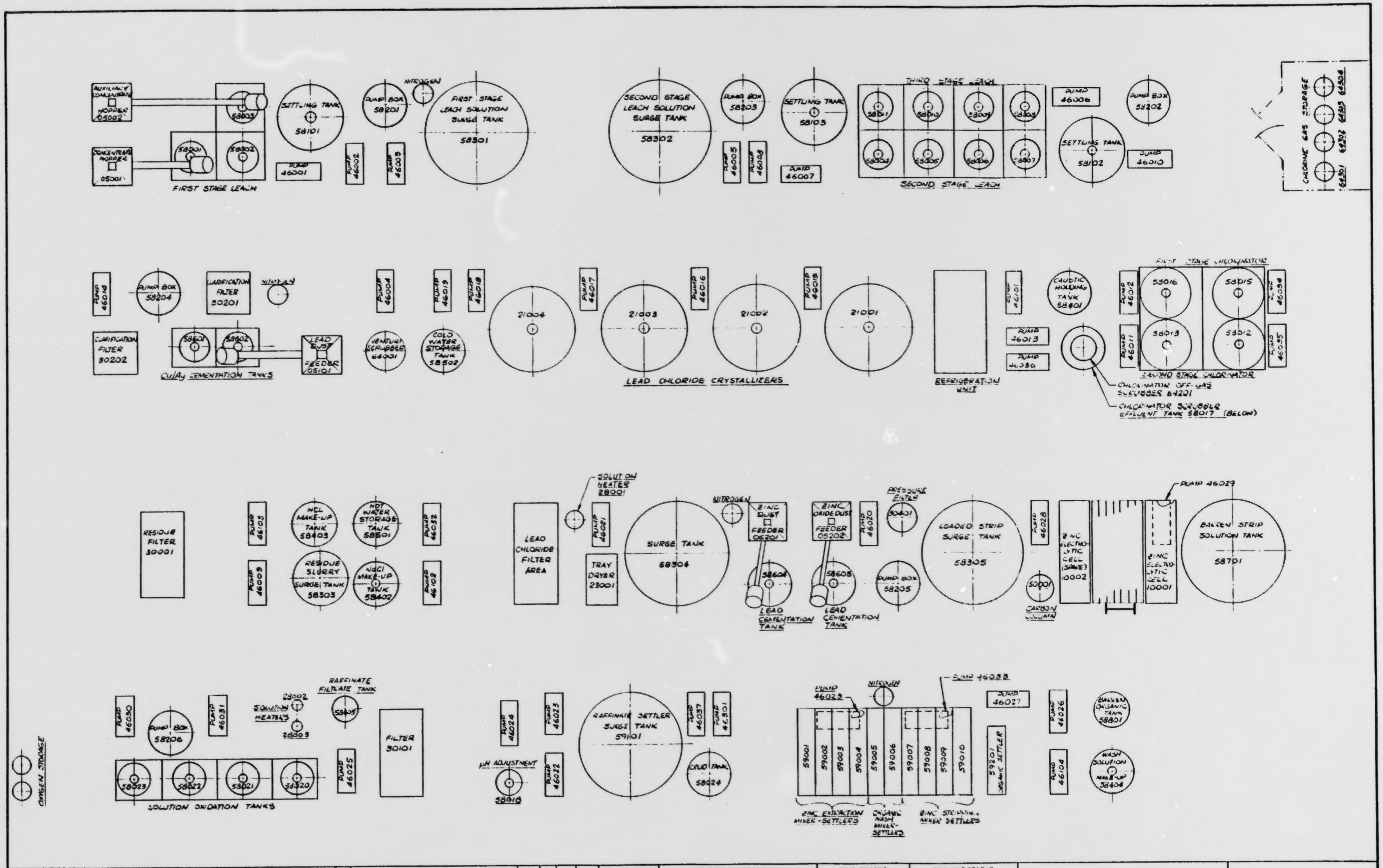
ELECTROWINNING & OXIDATION

STEARNS CATALYTIC

6221

080-004

REVISION 0


AUXILIARY CONCENTRATE HOPPER 05002
CONCENTRATE HOPPER 05001
58003
58001
58002
FIRST STAGE LEACH
SETTLING TANK 58101
PUMP 46001
PUMP 46002
PUMP BOX 58201
PUMP 46003
NITROGEN
FIRST STAGE LEACH SOLUTION SURGE TANK 58301
SECOND STAGE LEACH SOLUTION SURGE TANK 58302
PUMP BOX 58203
PUMP 46005
PUMP 46008
SETTLING TANK 58103
PUMP 46007
THIRD STAGE LEACH
58011
58010
58009
58008
58004
58005
58006
58007
SECOND STAGE LEACH
PUMP 46006
PUMP BOX 58202
SETTLING TANK 58102
PUMP 46010
CHLORINE GAS STORAGE
64301
64302
64303
64304
PUMP 46014
PUMP BOX 58204
CLARIFICATION FILTER 30201
NITROGEN
CLARIFICATION FILTER 30202
58601
58602
Cu/Ag CEMENTATION TANKS
LEAD DUST FEEDER 05101
PUMP 46004
VENTURI SCRUBBER 64001
PUMP 46019
COLD WATER STORAGE TANK 58502
PUMP 46018
21004
PUMP 46017
21003
PUMP 46016
21002
PUMP 46015
21001
LEAD CHLORIDE CRYSTALLIZERS
REFRIGERATION UNIT
PUMP 46101
PUMP 46013
PUMP 46036
CAUSTIC HOLDING TANK 58401
CHLORINATOR OFF-GAS SCRUBBER 64201
CHLORINATOR SCRUBBER EFFLUENT TANK 58017 (BELOW)
FIRST STAGE CHLORINATOR
PUMP 46012
PUMP 46011
58016
58015
58013
58012
PUMP 46034
PUMP 46035
SECOND STAGE CHLORINATOR
RESIDUE FILTER 30001
PUMP 46103
PUMP 46009
HCl MAKE-UP TANK 58403
HOT WATER STORAGE TANK 58501
RESIDUE SLURRY SURGE TANK 58303
NaCl MAKE-UP TANK 58402
PUMP 46032
PUMP 46102
LEAD CHLORIDE FILTER AREA
SOLUTION HEATER 28001
PUMP 46021
TRAY DRYER 23001
SURGE TANK 58304
NITROGEN
ZINC DUST FEEDER 05201
58604
LEAD CEMENTATION TANK
ZINC OXIDE DUST FEEDER 05202
58605
LEAD CEMENTATION TANK
PUMP 46020
PRESSURE FILTER 30401
PUMP BOX 58205
LOADED STRIP SURGE TANK 58305
PUMP 46028
50001
CARBON COLUMN
ZINC ELECTROLYTIC CELL (SPARE) 10002
ZINC ELECTROLYTIC CELL 10001
PUMP 46029
BARREN STRIP SOLUTION TANK 58701
OXYGEN STORAGE
PUMP 46030
PUMP BOX 58206
PUMP 46031
SOLUTION HEATERS 28002 28003
RAFFINATE FILTRATE TANK 58405
58023
58022
58021
58020
SOLUTION OXIDATION TANKS
PUMP 46025
FILTER 30101
PUMP 46024
pH ADJUSTMENT
58018
PUMP 46023
PUMP 46022
RAFFINATE SETTLER SURGE TANK 59101
PUMP 46037
PUMP 46301
CRUD TANK 58024
PUMP 46023
NITROGEN
PUMP 46033
PUMP 46027
59001
59002
59003
59004
59005
59006
59007
59008
59009
59010
ZINC EXTRACTION MIXER-SETTLERS
ORGANIC WASH MIXER-SETTLERS
ZINC STRIPPING MIXER SETTLERS
59201 ORGANIC SETTLER
PUMP 46026
PUMP 46104
BARREN ORGANIC TANK 58801
WASH SOLUTION MAKE-UP 58404

NO.	REVISIONS	DATE	BY	CHK	APPD	NO.	REFERENCE DRAWINGS
0	FOR ISSUE	85.04 28	H.R.				

ENG. RECORD

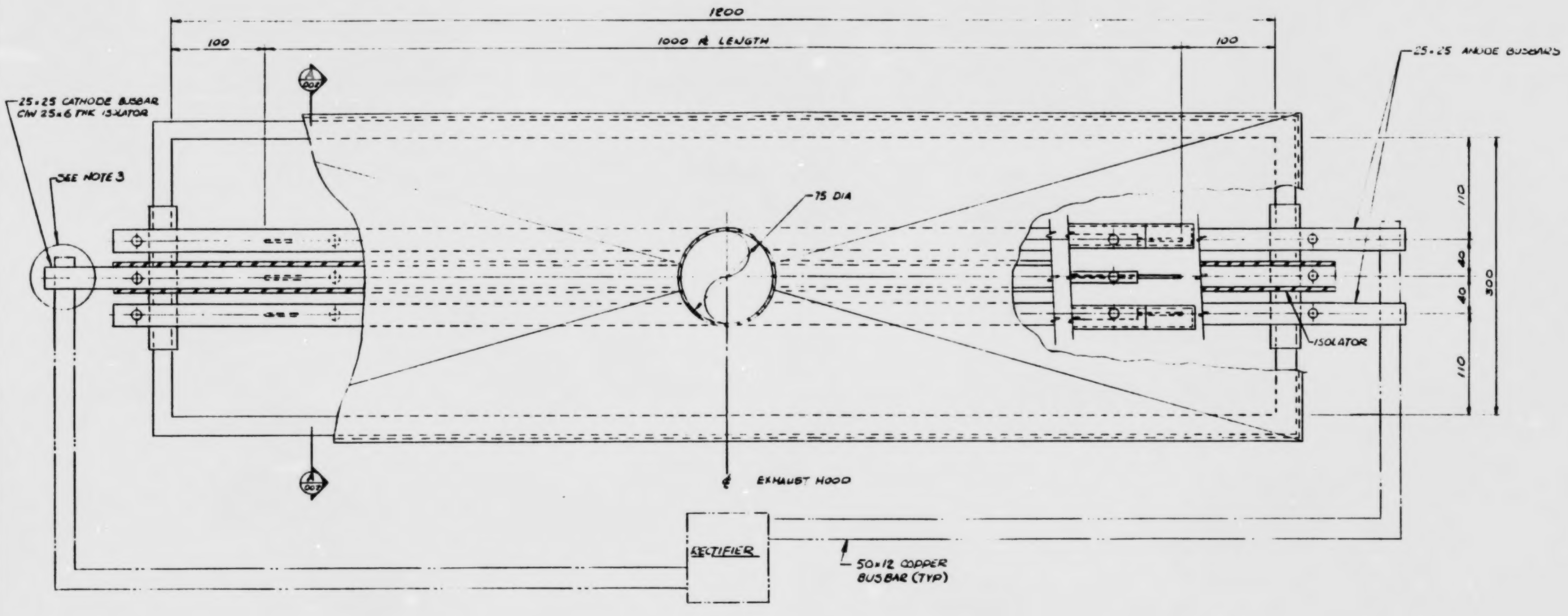
DRAWN	H.R.	85.04 01
PROJECT CH.		85.04 22

DRAWING STATUS

DSS – CANMET
FERRIC CHLORIDE LEACH
PILOT PLANT
PLAN

STEARNS CATALYTIC

PROJECT NO. 6221
S.C.L. DWG. NO. 090-001
SCALE 1:20
REVISION 0


1200
100
1000 ℄ LENGTH
100
25×25 ANODE BUSBARS
25×25 CATHODE BUSBAR C/W 25×6 THK ISOLATOR
SEE NOTE 3
75 DIA
A 002
A 002
110
40
40
110
300
ISOLATOR
℄ EXHAUST HOOD
RECTIFIER
50×12 COPPER BUSBAR (TYP)

-PLAN-

NOTES:

1. ELECTROLYTIC CELL TANK & EXHAUST HOOD FOR CHLORINE GAS TO BE FABRICATED FROM POLYCARBONATE SHEET.
2. SELLER TO CHECK & PROVIDE REQ'D STIFFENERS FOR TANK TO RESIST HYDROSTATIC LOADS.
3. SELLER TO PROVIDE RECTIFIER W/ISOLATED FEED BUSBARS TO ELECTRODES.
4. $2M^2$ OF ELECTRODE SURFACE EXPOSED TO $ZnCl_2$ SOLUTION.
5. ELECTROLYTE CURRENT DENSITY = 1000 A/m^2 OF EXPOSED ELECTRODE SURFACE.
6. DESIGN WT. OF CATHODE LOADED WITH Zn INCLUDING HARDWARE = 100 lbs.
7. SPACING BETWEEN ANODES & CATHODE IS ADJUSTABLE.
8. SOLUTION SPECIFIC GRAVITY = 1.11
9. ALL PIPE CONNECTIONS TO TANK & ANODE HOOD SHALL BE P.V.D.F. (KYNAR).

NO	REVISIONS	DATE	BY	CHD	APPD	NO	REFERENCE DRAWINGS
A	FOR APPROVAL/INQUIRY	83.03.19	H.R.			SK135-002	ZINC ELECTROLYTIC CELL-SECTIONS

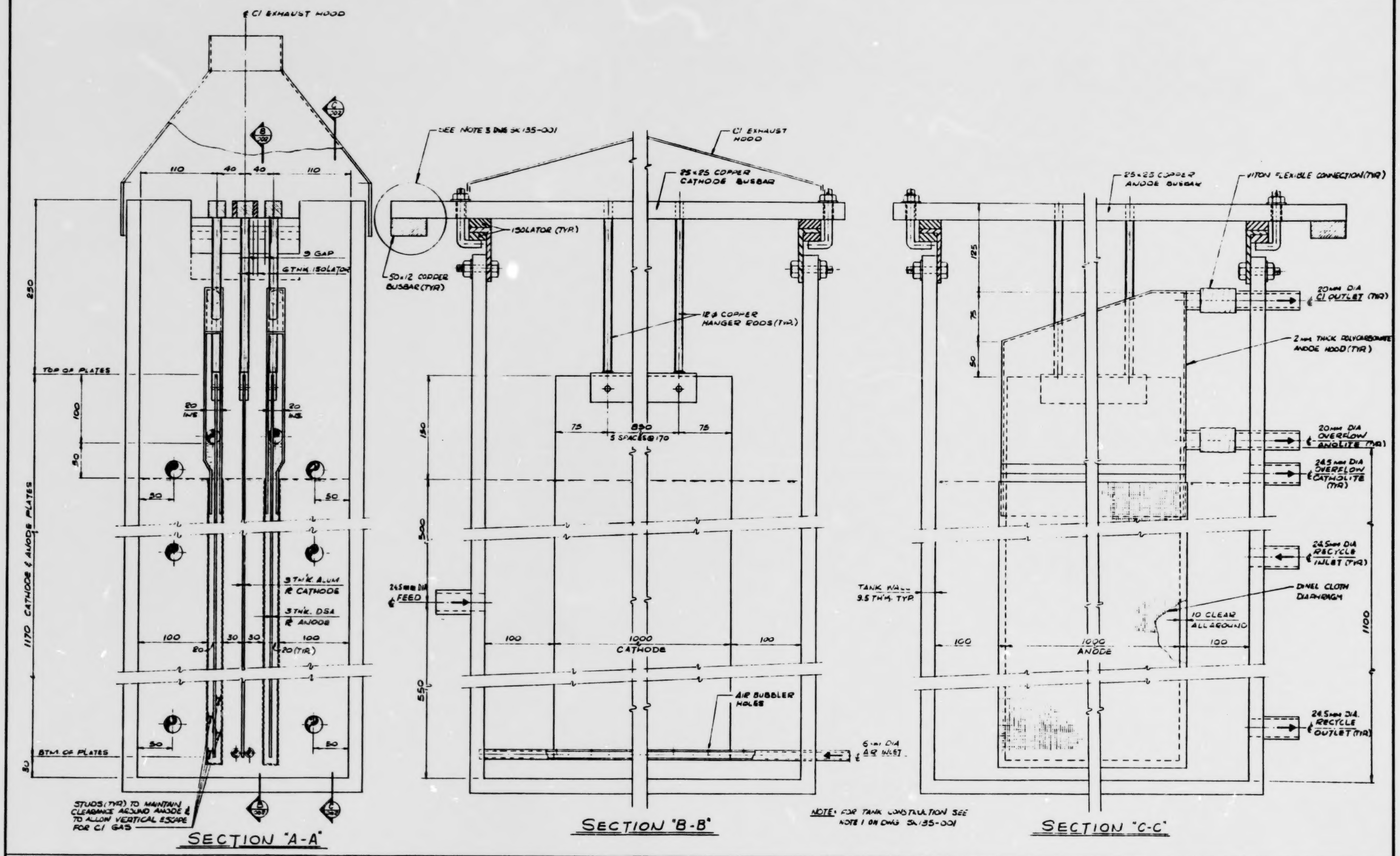
ENG. RECORD		
DRAWN	ABB	83.03.16
CHECKED		83.03.19
MECH CK		83.03.19
STRUCT CK		
ELECT CK		
PROCESS		
PROJECT CK		
PROJ. CK		83.03.19
CLIENT CK		
PROJ ENG		

DRAWING STATUS: PRELIMINARY / FOR COMMENTS AND/OR APPROVAL / APPROVED FOR CONSTRUCTION / REVISED & APPROVED FOR CONSTRUCTION

DSS - CANMET
FERRIC CHLORIDE LEACH
PILOT PLANT
ZINC ELECTROLYTIC CELL
PLAN

STEARNS CATALYTIC

CLIENT DWG NO
PROJECT NO 6221
SCE DWG NO SK 135-001
SCALE 1:25
REVISION A


℄ Cl EXHAUST HOOD
110
40
40
110
250
9 GAP
6 THK ISOLATOR
TOP OF PLATES
100
50
20 INS
20 INS
50
50
1170 CATHODE & ANODE PLATES
3 THK ALUM ℞ CATHODE
3 THK. DSA ℞ ANODE
100
30
30
100
20
20 (TYP)
50
50
BTM OF PLATES
30
STUDS (TYP) TO MAINTAIN CLEARANCE AROUND ANODE & TO ALLOW VERTICAL ESCAPE FOR Cl GAS
SECTION "A-A"
SEE NOTE 3 DWG SK 135-001
50×12 COPPER BUSBAR (TYP)
ISOLATOR (TYP)
Cl EXHAUST HOOD
25×25 COPPER CATHODE BUSBAR
12 ⌀ COPPER HANGER RODS (TYP)
75
850
75
5 SPACES @ 170
150
300
550
24.5 mm DIA ℄ FEED
100
1000 CATHODE
100
AIR BUBBLER HOLES
6 mm DIA ℄ AIR INLET
SECTION "B-B"
NOTE: FOR TANK CONSTRUCTION SEE NOTE 1 ON DWG SK 135-001
25×25 COPPER ANODE BUSBAR
VITON FLEXIBLE CONNECTION (TYP)
125
75
50
20 mm DIA ℄ Cl OUTLET (TYP)
2 mm THICK POLYCARBONATE ANODE HOOD (TYP)
20 mm DIA ℄ OVERFLOW ANOLITE (TYP)
24.5 mm DIA ℄ OVERFLOW CATHOLITE (TYP)
24.5 mm DIA ℄ RECYCLE INLET (TYP)
TANK WALL 9.5 THK. TYP.
DYNEL CLOTH DIAPHRAGM
10 CLEAR ALL AROUND
1100
100
1000 ANODE
100
24.5 mm DIA ℄ RECYCLE OUTLET (TYP)
SECTION "C-C"

NO	REVISIONS	DATE	BY	CHD	APPD	NO	REFERENCE DRAWINGS
A	FOR APPROVAL / INQUIRY	05 03 19	H.R.	JK		SK 135-001	ZINC ELECTROLYTIC CELL – PLAN

ENG RECORD
DRAWN ABB
DRAWING STATUS

DSS – CANMET
FERRIC CHLORIDE LEACH
PILOT PLANT
ZINC ELECTROLYTIC CELL
SECTIONS

STEARNS CATALYTIC

6221
SK 135-002
1:12.5
A

APPENDIX A

CANMET INSTRUCTIONS

CANMET $FeCl_3$ Leach Process

Figure 1 shows the flowsheet that is proposed by CANMET. Testwork to date has used a bulk concentrate produced at CANMET from Brunswick Mining and Smelting Co. complex sulphide ore.

Table 1 shows typical chemical analyses of the feed concentrate which is finely sized at 86.9 wt % - 44 µm and 76.4 wt % - 37 µm.

Table 1 - Chemical analyses of CANMET bulk concentrate (wt %)

Pb	8.75	Fe	19.1
Zn	28.1	Ag	233 g/t
Cu	0.78	S_T	35.0
		S/SO_4	1.51

Approximately 130 kg of concentrate is being forwarded under separate cover. The leach feed concentrate preparation as recommended by Bacon, Donaldson is advisable. Because of the fine grind considerable sulphate has formed. However leach conditions were found that minimized sulphate formation in the leach.

The following information sets out optimim conditions as found by CANMET for some unit operations to be confirmed; whereas for other unit operations, conditions found to date are presented.

1. Leach

Summary

A novel two-stage ferric chloride leach operation has been developed to:

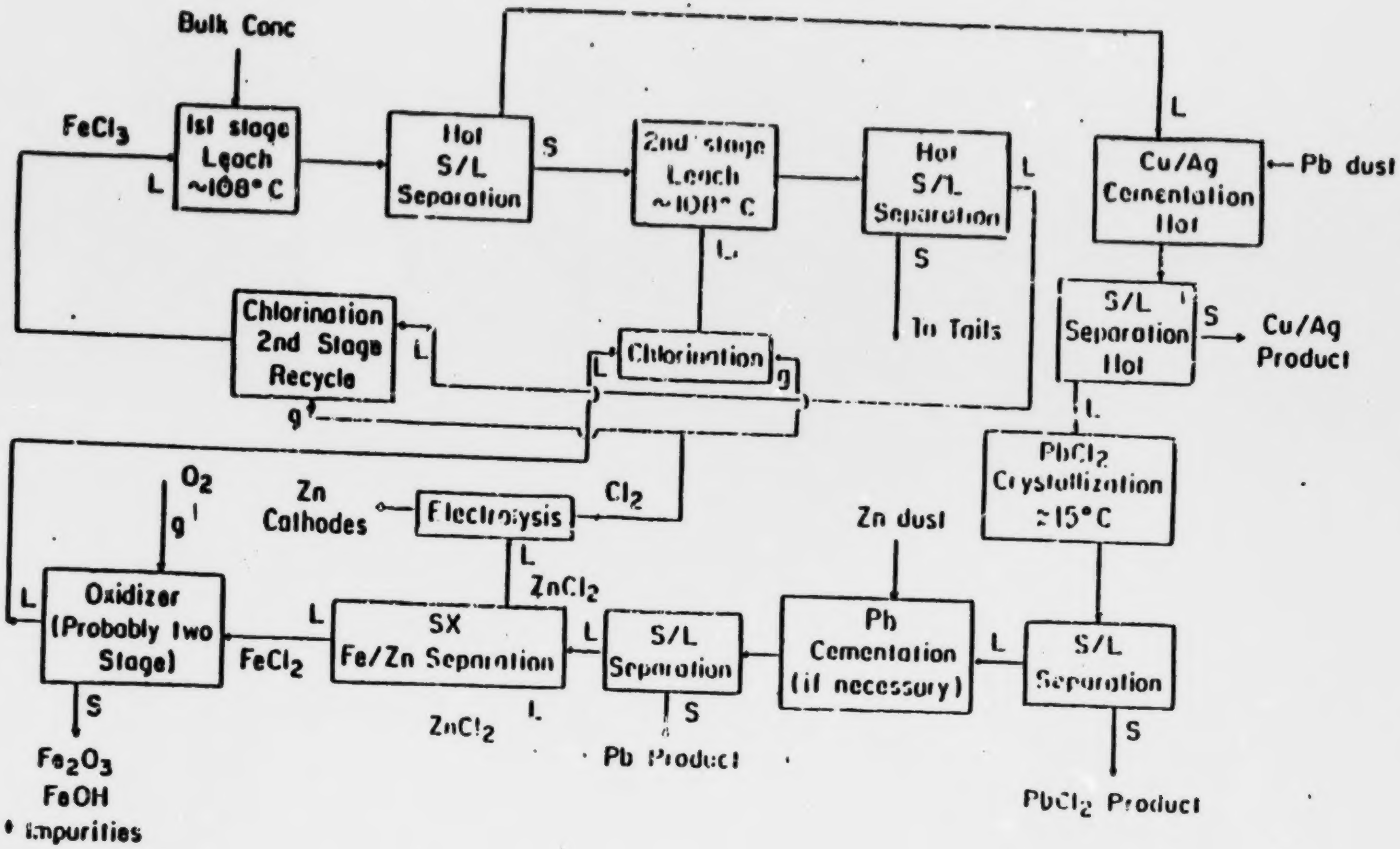
1) maximize the recovery of lead, zinc, copper and silver values.
2) produce a Zn/SX feed liquor containing a minimum of co-extractable Fe^{3+} values.
3) minimize soluble sulphate values.

Under the optimum conditions, (First stage; 108°C, 3.5 M NaCl. 0.43 M HCl, 50 g/L Fe^{3+}, 3.0 H. Second stage; 108°C, 3.5 M NaCl. 0.43 M HCl, 50 g/L Fe^{3+}, 4.5 h) the following was obtained:

1) respective extractions of lead, zinc, copper, and silver of 99.5, 98.3, 93.9, and 91.6 per cent.
2) a liquor for cementation treatment containing from 0.0 to 1.3 g/L Fe^{3+}.
3) conversion of sulphur to soluble sulphate of from 0.91 to 2.4 per cent.

TWO-STAGE LEACH

CANMET flowsheet


Bulk Conc
FeCl3
L
1st stage Leach ~108° C
Hot S/L Separation
S
2nd stage Leach ~108° C
Hot S/L Separation
L
S
To Tails
L
Cu/Ag Cementation Hot
Pb dust
S/L Separation Hot
S
Cu/Ag Product
L
Chlorination 2nd Stage Recycle
L
g
Chlorination
L
g
O2
g
Zn Cathodes
Electrolysis
Cl2
L
ZnCl2
PbCl2 Crystallization ≈15°C
Zn dust
L
Oxidizer (Probably Two Stage)
L
FeCl2
SX Fe/Zn Separation
L
S/L Separation
Pb Cementation (if necessary)
L
S/L Separation
S
Fe2O3
FeOH
Impurities
ZnCl2
L
S
Pb Product
S
PbCl2 Product

PROPOSED TWO-STAGE FERRIC CHLORIDE LEACH PROCESS FLOWSHEET.

Figure 1.
Proposed CANMET Flow Sheet

The following is the bench-scale leach procedure used at CANMET. Volumes and weights for the layer leach can be factored up while in other areas, e.g., L/S separation and washing, conditions, etc. will be developed for the continuous pilot plant.

Bench-Scale Leaching Procedures and Conditions

Leachant Composition - 50 g/L Fe^{3+}, 3.5 M NaCl, 0.43 M HCl, 1.5 L
Leachant Preparation - First stage. First cycle (1-1)

1) Add 62.5 g Fe^{3+} (as $FeCl_3 \cdot 6H_2O$ reagent grade) to 1.0 L of distilled water
2) Mix under heat to 75°C
3) Add while stirring 45.6 mL of concentrated HCl (HCl 36.5 to 38.0%)
4) Add 306.8 g of NaCl (reagent on technical grade). Adjust the solution volume to 1.5 L (hot)
5) Allow the solution to cool to room temperature. Adjust to 1.5 L (cold), sample.

Leaching (I-1) First Stage First Cycle: (202.5 g of concentrate, 1.25 L of $FeCl_3$ leachant) 108°C, 3.0 h, 600 RPM

1) In a sealed and baffled 2.0 L glass reaction vessel, heat under agitation 1.0 L of $FeCl_3$ leachant. Allow the condensate to return to the reaction vessel.
2) Add $PbCl_2$ (reagent grade) to obtain 12.0 g/L Pb.
3) When the leach solution is at temperature, add 100 mL of $FeCl_3$ leachant. Slowly add 202.5 g of concentrate (the reaction is exothermic). Clean out the concentrate sample bottle using the 150 mL of $FeCl_3$ leachant.
4) Allow the slurry to heat to temperature. t = 0.0 h. Continue the leaching for 3.0 h.

L/S Separation and Wash - First Stage

1) Immediately separate the hot first stage leach slurry. The use of a pressure filter under nitrogen is preferred over a 15 cm vacuum filter.
2) In either case, use a Whatman #3 filter paper.

3) Record the volume of first stage pregnant solution sample, and maintain the solution temperature at $T \geq 85^{\circ}C$. Use hot pregnant to clean out the reaction vessel. Filter the slurry and collect the bulk first stage residue and pregnant.
4) Record the weight of the bulk first stage residue (1-1-k) and secure a sample of approximately 10 g. Repulp the 10 g sample in 50 mL of 70°C 1 M NaCl, filter, and give 3 x 50 mL 70°C H_2O displacement washes.
5) Dry the washed sample at 85°C overnight. Record the dry weight, and submit for assay. Retain the unwashed bulk residue as the feed material for stage two. Do not dry the bulk residue.

Leachant Preparation - Second Stage First Cycle (2-1)

1) The leachant composition and preparation for (2-1) is identical to (1-1) with the following exception. Immediately prior to adjusting the hot solution volume (1.5 L), add $ZnCl_2$ for 4.0 g/L Zn.

Leaching (2-1) Second Stage First Cycle - 108°C, 4.5 h, 600 RPM

1) Proceed as per (1-1). Heat a measured volume of 2-1 leachant; add $PbCl_2$; heat to temperature; add a portion of 2-1 leachant; add the moist 1-1 bulk residue; clean out the solids using the remaining volume of 2-1 leachant; add the clean out slurry to the reaction vessel.
2) At $T = 108^{\circ}C$, $t = 0.0$ h. leach for 4.5 h

L/S Separation and Wash - Second Stage

1) Proceed as per (1-1). Filter hot; record the pregnant volume; sample the pregnant; maintain the bulk pregnant at $T \geq 85^{\circ}C$. Transfer the bulk 2-1 residue to the repulp vessel. Use 1 x 200 mL of 70°C 1 M NaCl to clean the filter paper.
2) Repulp the bulk 2-1 residue. Filter, wash the cake with 2 x 200 mL 70°C, H_2O. Combine the wash and save.

Chlorination of 2-1 Pregnant & Wash

The wash solution is assumed to contain only water and requires make-up.

1) Measure the volumes of 2-1 pregnant and wash. Charge both solutions to a sealed and baffled 2.0 L glass reaction vessel. Operate the reaction vessel under reflux and moderate agitation.
2) Add $FeCl_3 \cdot 6H_2O$, NaCl, and HCl (to obtain 50 g/L Fe^{3+}, 3.5 M NaCl, and 0.43 M HCl respectively) for the volume of wash added.
3) Heat to 80°C. Sparge the solution with Cl_2 gas for 2.5 h at 71 mL/min.
4) Measure the volume of regenerated leach liquor and retain for use in the subsequent first stage leach.

Leaching (1-n) First Stage nth Cycle

Conditions: As per 1-1 but use the chlorine regenerated pregnant and wash obtained from the previous second stage leach.

Leaching (2-n) Second Stage nth Cycle

Conditions: As per 2-1 with the following exception. When using the recycle liquor (after Fe elimination and chlorination) do not add $PbCl_2$ or $ZnCl_2$.

NOTES:

1. The volume of Cl_2 for chlorinating the leachant solutions is based on stoichiometric Cl_2 from Zn and Pb electrolyses. The Cl_2 is evenly split between the two streams. Since $FeCl_3$ is regenerated to some degree in the recycle stream after iron elimination by oxidation, the extra Cl_2 will form HCl and possibly some HOCl. The same will hold true in the stage II recycle leachant where some $FeCl_3$ is recycled.
2. The purpose of the split chlorination is to produce leachants with $Fe_T = Fe^{+3}$ and no Fe^{+2}. It has been found that this allows the Fe^{+3} to be more fully consumed, and in most 1st stage leaches final. Fe^{+3} is less than 0.5 g/L.
3. The 50 g Fe^{+3}/L in the leachant is based on 2 leach stages and therefore presents 100 g Fe^{+3}/L to the concentrate charge. By stoichiometry, this is about 25% excess Fe^{+3}. It has been found that a lower concentration of Fe^{+3} reduces the amount of SO_4 formed while still maintaining good metal extraction.

2. Liquid/Solid Separation and Washing

The following is abstracted from Dutrizac concerning bench-scale leach tests:

"Although the bulk concentrates themselves, especially the second batch, were very fine grained, the leach residues settled and filtered fairly well without the use of flocculants. There are likely two reasons for the favourable settling properties. Firstly, the extremely fine particles are likely dissolved during the leaching period and this would leave the coarser grains which would settle better. Secondly, the elemental sulphur reaction product at 102°C is "sticky" and tends to agglomerate all the particles into coarser, easily filtered grains. The time to filter 2 L of hot leach slurry (with ≈190 g leach residue) on a 24-cm diameter Buchner vacuum filter was 85–90 s. The calculated average filtration rate was then 0.051 $mL/cm^2 \cdot s$; that is, the filtration rate is greater than 2,000 $kg/m^2 \cdot h$.

The residues were readily washed with 95-100°C water to remove entrained salts or $PbCl_2$ crystals. Since the lead content of the residue reflects mostly $PbCl_2$ plus minor unleached PbS, it is probably a good indicator of the washing efficiency. The following data show the lead concentration of the residue after washing with incremental amounts of hot (100°C) water.

Wash Water	% Pb in Residue
0 x 200 mL	0.59
1 x 200 mL	0.16
2 x 200 mL	0.30
3 x 200 mL	0.12
4 x 200 mL	0.14

The relatively high lead content (0.59 wt %) of the filtered but not washed residue indicates entrainment of the pregnant solution with its associated $PbCl_2$. The 0.12-0.14% Pb values of the well-washed residues probably reflect the residual PbS values. Within this framework, it is apparent that only one or two 200 mL washes would be needed to remove the entrained solutions; i.e. the filtration water (or recycled solution) demand is only 5-10% of the leach volume.

It would likely be desirable to thicken the hot leach residues either before hot filtration or for recycle to a second stage of leaching. Standard settling tests were done using a 2000 mL graduated cylinder to ascertain both the settling rate and the relative clarity of the supernatant liquid. These tests were complicated by the crystallization of $PbCl_2$ that commenced at about 85–90°C for leaching done under the preferred conditions. After 5 min of settling, it appeared that all the solids had settled to 240 mL of pulp leaving behind a cloudy fluid. After 20 minutes, the temperature had fallen to 87°C and $PbCl_2$ crystal formation in a relatively clear fluid commenced. Ater 50 minutes the solution was clear except for a "rain" of relatively coarse $PbCl_2$ crystals; the volume of the pulp was about 228 mL. After 48 h, the fluid was clear, and the sulphide pulp (225 mL) was covered by about 100 mL of $PbCl^2$ crystals.

The above observations suggest that the thickening and filtration of the hot slurries should be relatively simple; the major problem will be to ensure that the system remains above the crystallization temperature for $PbCl_2$."

PILOT PLANT I

The leach slurry was discharged by gravity to a 44-cm diam rubber-coated pan filter which had a cover fitted to allow pressure filtration. The unit was insulated to maintain a slurry temperature of about 90°C so as to maintain $PbCl_2$ solubility. Washing was effected by the application of 3 batches of 5 L H_2O at 90°C, for ~5 Kg leach residue.

Observations

The slurry filtered very quickly but the washing was poor. On inspection it was found that the center of the cake was very thin allowing short-circuiting of the wash water. Considerable $PbSO_4$ and $PbCl_2$ crystals remained in the residue.

PILOT PLANT II

To correct the above problems, a deflector plate was placed in the center of the pan filter to overcome the short-circuiting. The washing technique for the second pilot plant was changed to 2-1 L displacement washes of 1 M NaCl followed by 2-1 L displacment washes of water, all at 90°C. The washing efficiency is plotted in Figure 2.

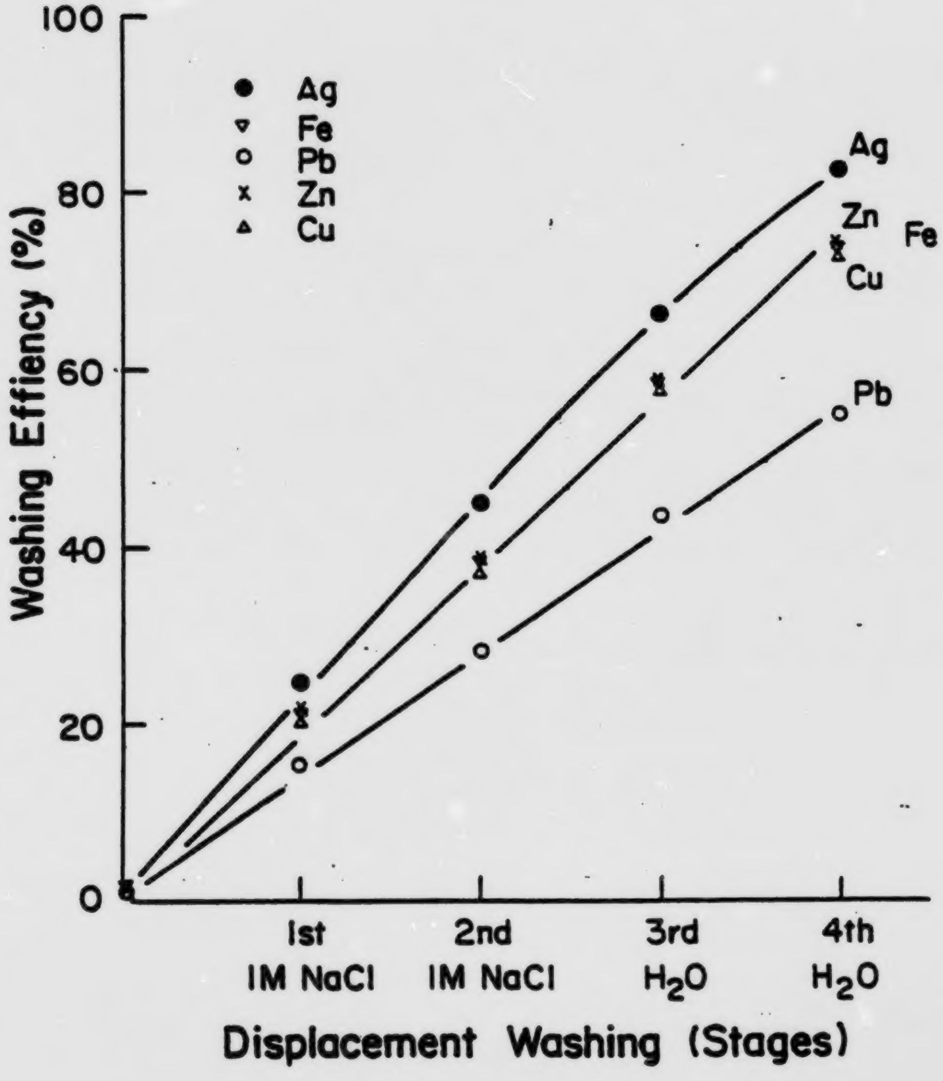


FIGURE 2: Displacement Washing Efficiency in Pilot Plant II

Observations

It is obvious that displacement washing was efficient for Ag, Cu, Fe and Zn but was short of sufficient stages. However, elimination of soluble Pb was less efficient. The data suggest that a hot repulp in a brine solution stronger than 1 M NaCl may be necessary followed by displacement washes. It was calculated that there were approximately 3 L of leach liquor to displace. Only 4 L of wash water were used which would indicate that the leach residue is easily washed. Because of the close water balance requirements for a leach circuit using a recycle liquor, wash water was minimized. The wash water was added to the leach liquor and evaporation used to maintain the water balance.

3. Cu, Ag Cementation

It is desirable to reach a residual 0.001 g Cu, Ag/L in the Zn electrolyses feed. It is felt that can be obtained for Cu and Ag by cementation. Since the cementation operation is necessary and relatively inexpensive it is better to try and reach the low Ag, Cu values at this time rather than in the more difficult SX purifying stage. It should be noted that it is possible to selectively leach Pb from the cement product and thus create a saleable Ag, Cu product.

Following are the conditions to be tested for Cu, Ag cementation: $T \geq 85^{\circ}C$; N_2 atmosphere; rapid stirring; the amount of Pb dust to be used is at least 2X stoichiometric requirement. The stoichiometric requirement of Pb dust is based on the concentration of all species in the leach solution which can be reduced by Pb, including Ag^{+}, Cu^{+}, Cu^{++}, Bi^{+++}, Fe^{+++}, etc. Retention is 10 min.

NOTES:

1) Pb powder is preferred over granular Pb as the reaction is more rapid and complete.
2) The HCl concentration effect was not studied.
3) The complete report on the latest testwork is appended.

4. $PbCl_2$ Crystals

The following notes are a summary of what data CANMET has:

In the first pilot-plant campaign the leach liquor was cooled rapidly after cementation with the result that very fine $PbCl_2$ crystals formed which were difficult to handle. To increase the $PbCl_2$ solubility 1 M NaCl was added to the leachant for the second pilot plant, and leach liquor cooled slowly so as to increase $PbCl_2$ crystal size. The lead product was washed with saturated $PbCl_2$ solution.

The following procedure was used:

$PbCl_2$ = 465.9 g
Displacement wash = 4 x 250 mL
sat $PbCl_2$ solution

The dried product after the washing had a light brown stain possibly due to entrained iron. The crystals were repulped in 800 mL followed by 2 x 250 mL displacement washes with $PbCl_2$ solution.

The purity of the $PbCl_2$ crystals was as follows:

SO_4 = 7.113%
Zn = 0.005%
Cu = 0.0001%
Ag = 0.0001%
Fe = 0.0001%
Cd = 0.0001%
Bi = 0.0001%

The $PbCl_2$ crystals recovered from the second pilot plant had the following screen analysis:

	Wt %		Wt %
+ 297 µm	12.4	−105 µm + 74 µm	9.4
−297 µm + 210 µm	8.7	− 74 µm + 53 µm	6.4
−210 µm + 149 µm	10.5	− 53 µm	43.4
−149 µm + 105 µm	9.2		

CANMET is not enthused about $CaCl_2$ as a means to precipitate the sulphate as there is a danger of a saturated leach liquor having post precipitation of $CaSO_4$. This was found by the USBM (Report 8770). If $CaCl_2$ was used we have found the following solubility data:

HCl Conc'n M	Sol $CaSO_4$ (g/L)		Sol $PbCl_2$ (g/L)	
	18°C	25°C	10°C	25°C
0.2		5.6	1.4	1.84
0.5		10.2	1.2	1.42
1.0		14.2	1.2	1.36
5.78		10.4	5.2	3.90

Therefore, if $CaCl_2$ was used, a $PbCl_2$ wash using 1.0 N HCl is indicated.

If sulphate formation in the concentrate can be reduced prior to the leach and minimized in the leach, it might be economical to consider $BaCl_2$ treatment of the leach liquor to precipitate sulphate.

This $BaSO_4$ ppte could possibly be leached to take out metal impurities (e.g., 3% Pb) and sold or $BaCl_2$ could be reformed at the mill site.

5. Zinc SX

Testwork is on-going and conditions will be supplied in January 1985. An N_2 atmosphere will have to be maintained on stored leach liquor for subsequent use in SX so as to prevent oxidation of the ferrous iron.

6. Oxidation for Fe Removal

We have not tested conditions on a large scale. One bench test found air very slow. Therefore, O_2 is preferred. Bench testwork is on-going and some or all conditions can be recommended at a later date.

7. Chlorination of Recycle Liquors

This operation seems straight forward and is more of a case of equipment selection and absorption optimization.

APPENDIX A

The following list indicates the phone numbers by which to contact CANMET personnel and their area of expertise:

			(area code 613)
1.	Leaching	a) B.H. Lucas	995-4221
		b) D.Y. Shimano	995-4114
2.	Cementation	Dr. D.J. MacKinnon	995-4851
3.	$PbCl_2$	Dr. J.E. Dutrizac	995-4823
4.	Zinc SX	a) G.M. Ritcey	995-4124
		b) Dr. R. Molnar	995-4221
5.	Fe Oxidation	a) Dr. J. Dutrizac	995-4823
		b) E. Rolia	995-4798
6.	Chlorination	a) Dr. J. Dutrizac	995-4823
		b) D.Y. Shimano	995-4114

FERRIC CHLORIDE LEACHING OF SULPHIDE MINERAL CONCENTRATES
PHASE II
APPENDIX B

BACON, DONALDSON

& ASSOCIATES LTD.

VANCOUVER, B.C. CANADA

BACON,
DONALDSON
& ASSOCIATES LTD.

2036 COLUMBIA STREET
VANCOUVER B.C. CANADA V5Y 3E1
TELEPHONE (604) 879-8461
TELEX 04-53437

FERRIC CHLORIDE LEACHING OF SULPHIDE MINERAL CONCENTRATES
PHASE II
APPENDIX B

Laboratory Testwork Details

DSS FILE NO. 23SQ.23440-4-9202
CONTRACT SERIAL NO. OSQ84-00290
BDA PROJECT NO. 5371

Part of the Canada/New Brunswick
Mineral Development Agreement

June 1985

B.1 Sampling and Analysis

B.1.1 Sampling Numbering System

All the samples taken on this project had the prefix D. The next digit was the unit operation number.

1 = 1st stage leach
2 = 2nd and 3rd stage leaches
3 = 1st stage chlorination
4 = Cementation
5 = $PbCl_2$ crystallization
6 = Solvent extraction
7 = Turboaeration

This was followed by a hyphen (-) and the two digit test number, e.g. Test 1 = 01, and then by the sample time or sample number.

The 3rd stage leach tests were conceived after the numbering system was established. The first 3rd stage leach was number D2-50.

B.1.2 Sampling Procedures

Liquids: All liquids were sampled hot (if required). There was a small systematic error due to this technique caused by the volume change of the pipette with temperature. A 5 ml pipette delivers 4.85 ml at 100°C. Corrections for this factor were not made.

Various primary liquid samples were taken corresponding to the species to be assayed:

i) atomic absorption sample for Na, Zn, Pb, Cu, 5 ml diluted to 100 ml in 20 % HNO_3, Cl^- by titration

ii) sample for Total Fe and Fe^{2+} titration, 5 ml diluted to 100 ml in 20 % HCl

iii) sample for Ag, 25 ml direct

iv) sample for Fe^{3+} titration, 5 ml direct with 5ml HCl

v) sample for SO_4^{2-}, 10 ml direct

vi) sample for HCl titration, 5 ml diluted to 100 ml with water

Slurries: Slurry samples were taken using tipless pipettes. These were then filtered using a preheated 4.25 cm filter under the pressure of a squeeze bulb. The filtrate was sampled directly (as above) and the solids were washed with appropriate solutions and dried at 60°C.

B.1.3 Solution Specific Gravity

Many of the solutions precipitated $PbCl_2$ if allowed to cool and so most of the solution specific gravities were determined at 90° C. These gravities were calculated by weighing a tared 100 ml volumetric flask full of hot solution and adjusting for the measured hot volume of the flask.

B.1.4 Solids Digestion

Solids were digested for metal and sulphur determination. A portion of the solids was digested in HNO_3 and Br_2, taken to dryness, made up in HCl, filtered and washed. The solids that did not dissolve constituted the insoluble (insol) fraction.

B.1.5 Chemical Analysis Methods

Na, Pb, Zn and Cu: Determined by atomic absorption.

Fe^{2+}: Determined by a potentiometric titration with 0.1 N $K_2Cr_2O_7$ on a Mettler DL40 automatic titrator.

Total Fe: Determined as Fe^{2+} following a reduction with $SnCl_2$.

Fe^{3+}: Determined by a potentiometric titration with 0.1 N $SnCl_2$ on a Mettler DL40 automatic titrator.

Cl^-: Determined by a potentiometric titration with 0.1 N Ag NO_3 on a Mettler DL40 automatic titrator.

S and $SO_4{}^{2-}$ in solution: Determined gravimetrically as $BaSO_4$ after removal of Pb from solution by Na_2CO_3.

Ag in solution: Determined by fire assay after cementing the silver on zinc dust with copper sulphate added as a collector.

Au and Ag: Determined by fire assay.

HCl: Determined by potentiometric titration with 0.1 N NaOH after the addition of the sample to an aliquot of 0.05 M MgDCTA.

B.2 Test Sequences

A guide to the test results showing the sequence of the various tests which were done follows. Fresh concentrate was added in the 1st stage leach in each row of Table B.1 and these solids were carried along through the 2nd and 3rd stage leaches. The solution produced in the 1st stage leach was carried through the cementation, crystalization and solvent extraction steps in each row. The solution produced in the second stage was carried to the chlorination step.

TABLE B.1
TEST NUMBER GUIDE

1st Stage Leach Date	1st Stage (Leach D1)	2nd Stage (Leach D2)	3rd Stage (Leach D2)	Chlorine (D3)	Cement (D4)	$PbCl_2$ Crys(D5)	Solvent Extraction (D6)
01/18/85	12	12				22	13
01/22/85	13	13		10		11/13	
01/24/85	14						
01/28/85	15	15	50	11		24/28	
01/30/85	16	16	51	12		15/29	
01/31/85	17						
02/01/85	18	18	52	13			
02/05/85	19						
02/06/85	20	20	53	14	10		
02/07/85	21	21	54	15			
02/12/85	22	22	55	16			
02/18/85	23	23	56	17		18	9
02/20/85	24	24	57	18		19	10
02/22/85	25	25	58	19		20	11
02/26/85	26	26	59	20		21	12
02/28/85	27	27	60	21			
03/05/85	28	28	61	22/23		23	14
03/08/85	29	29		24			
03/11/85	30	30	62	25	16	29	15
03/26/85	31	31			17/18		

LEACH TEST: D1-12

PRODUCTS:

SUPERNATENT LIQUID: 16.24 kg

SETTLED SOLIDS: 2.76 kg: 62%
SOLIDS: 1.70 kg
LIQUID: 1.06 kg

TOTAL LIQUID: 17.3 kg sg: 1.28
VOLUME: 13.52 l

LEACH TEST: D1-12 DATE: 02/19/85

SOLUTION:
NEW SOLUTION: 18.86 kg
TOTAL SOLUTION: 18.86 kg sg: 1.226 g/cc
VOLUME: 15.39 l

NEW SOLUTION:
H_2O: 11.72 kg
$FeCl_3 \cdot 6H_2O$: 3.630 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$:
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE: 2.436 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 3 hr
TEMPERATURE: 105-106.5°C

NOTES: 1) Weight of concentrate lost, adhered to bag - 4.1 g
2) Solids lost in filtering pregnant solution - 16.0 g

SOLUTION ASSAYS TEST: D1-12

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Au (ppm)
0	0.0	11.8	0.04	48.2	0.0	182.5	55		0.45	1.32
0.5	24.5	25.5	0.49	49.2	47.2	182	58			
1.0	24.8	25.2	0.49	50.1	47.8	184	55			
2.0	25.0	25.3	0.48	49.4	46.8	186	56			
2.5	24.8	25.7	0.49	49.0	46.8	187	54			
3.0	24.4	25.5	0.49	49.1	46.6	189	54		9.60	18.5

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.5	18.5	0.13	0.67	21.4				
1.0	17.6	0.12	0.66	21.3				
1.5	19.3	0.12	0.72	26.3				
2.0	18.3	0.11	0.71	21.1				
2.5	18.4	0.11	0.69	20.4				
3.0	18.0	0.10	0.71	21.3				
Final	18.0	0.10	0.71	21.3	49.5	1.34	144	1.13
% Remain.	44	0.8	61	87	97		46	111

MASS BALANCE LEACH TEST: D1-12

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLUTION	TOTAL	SOLIDS	SOLUTION	TOTAL		
Na			1,034	1,034		731	731	303	29
Fe	421		750	1,171	365	665	1,030	141	12
Zn	695			695	305	330	635	60	9
Pb	241		180	394	2	345	347	47	12
Cu	19.5			19.5	11.9	6.6	18.5	1.0	5
Cl			3,307	3,307		2,552	2,552	755	23
S	872			872	843	43	886	(14)	
SO_4^{2-}									
Au*	1.7			1.7	1.9		1.9	(0.2)	
Ag*	532			532	246	251	497	35	7
H_2O**			13.6	13.6		12.6	12.6	1.0	7
TOTAL**	2.4		18.9	21.3	1.7	17.3	19.0	2.3	11

* mg

** kg

LEACH TEST: D2-12

PRODUCTS:

SUPERNATENT LIQUID: 17.9 kg

SETTLED SOLIDS: 2.36 kg

SOLIDS: 1.77 kg: 75%

LIQUID: 0.59 kg

TOTAL LIQUID: 18.5 kg sg: 1.27

VOLUME: 14.56 l

LEACH TEST: D2-12 DATE: 01/19/85

SOLUTION: kg from Test:

NEW SOLUTION: 18.68 kg

TOTAL SOLUTION: 18.68 kg sg: 1.26

VOLUME: 14.87 l

NEW SOLUTION:

H_2O: 11.4 kg

$FeCl_3 \cdot 6H_2O$: 3.63 kg

NaCl: 2.63 kg

$PbCl_2$: 0.24 kg

$ZnCl_2$: 0.13 kg

Conc HCl: 0.546 l

: 0.64 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.56 kg from Test: D1-12

SOLIDS: 1.58 kg : 62%

LIQUID: 0.98 kg sg: 1.28

VOLUME: 0.76 l

CONDITIONS:

TEST DURATION: 4.5 hr

TEMPERATURE: 106°C

MASS BALANCE LEACH TEST: D2-12

(g)	IN				OUT			DIFF. IN-OUT (gain)	% $\triangle$/IN
	SOLIDS	SLURRY LIQUID	SOLUTION	TOTAL	SOLIDS	SOLUTION	TOTAL		
Na		41	1,034	1,075		1,080	1,080	(5)	
Fe	339	37	750	1,126	305	713	1,018	108	10
Zn	283	19	60	362	20	340	360	2	1
Pb	2	19	180	201	2	178	180	21	10
Cu	11.1	0.4		11.5	1.0	7.6	8.6	2.9	25
Cl		144	3,378	3,522		3,284	3,284	238	7
S	783	2		785	651	13	664	121	15
SO_4^{2-}									
Au*	1.8			1.8	4.0		4.0	(2.2)	
Ag*	228	14		242	58	172	230	12	5
H_2O**		0.7	13.3	14.0		13.5	13.5	0.5	4
TOTAL**	1.6	1.0	18.7	21.3	1.1	19.1	20.2	1.1	5

* mg

** kg

SOLUTION ASSAYS TEST: D2-12

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	3.7	10.2	0.03	49.8	0.0	208	75		0.20	1.36
0.5	16.9	11.2	0.26	48.9	33.6	211	74			
1.0	18.7	11.4	0.33	49.1	36.9	211	75			
1.5	19.8	11.8	0.38	48.8	39.6	215	80			
2.0	22.7	13.2	0.46	48.8	41.3	235	76			
2.5	20.9	11.7	0.44	48.0	42.3	220	76			
3.0	21.8	11.7	0.48	48.2	43.2	215	75			
3.5	23.4	12.2	0.49	46.6	44.1	217	74			
4.0	22.7	12.1	0.50	47.1	43.7	214	74			
Final 4.5	28.5	11.8	0.50	47.2	46.8	217	72		2.55	11.4

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.5	7.6	0.11	0.52	28.1				
1.0	6.3	0.09	0.44	24.6				
1.5	4.9	0.09	0.37	25.1				
2.0	4.0	0.08	0.32	24.6				
2.5	3.2	0.09	0.30	25.5				
3.0	3.1	0.08	0.29	25.4				
3.5	2.5	0.09	0.27	25.6				
4.0	2.3	0.08	0.26	25.5				
4.5	1.97	0.09	0.23	25.8				
Final	1.97	0.09	0.23	27.0	57.7	1.34	51.7	3.53
% Remain.	7.0	100	9.0	90	83		25	

LEACH TEST: D1-13

PRODUCTS:

SUPERNATENT LIQUID: 16.2 kg

SETTLED SOLIDS: 3.02 kg
SOLIDS: 1.74 kg: 58%
LIQUID: 1.28 kg

TOTAL LIQUID: 17.5 kg sg: 1.34
VOLUME: 13.04 l

LEACH TEST: D1-13 DATE: 01/22/85

SOLUTION: 16.3 kg from Test: D2-12 (D3-09)
NEW SOLUTION: 1.50 kg
TOTAL SOLUTION: 17.8 kg sg: 1.28
VOLUME: 13.8 l

NEW SOLUTION:
H_2O: 1.50 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.435 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 3.0 hr
TEMPERATURE: 105-107°C

NOTES: Solids left on filter paper at end of run - 27 g

MASS BALANCE LEACH TEST: D1-13

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na			948	948		819	819	129	14
Fe	421		711	1,132	341	702	1,043	89	8
Zn	695		298	993	314	602	916	77	8
Pb	214		168	382	3	331	334	48	13
Cu	19.5		6.9	26.4	12.3	12.9	25.2	1.2	5
Cl			3,242	3,242		3,004	3,004	238	7
S	872		14	886	793	54	847	39	4
SO_4^{2-}									
Au*	1.7			1.7	1.5		1.5	0.2	12
Ag*	532			532	241	465	706	(174)	
H_2O**			12.9	12.9		11.9	11.9	1.0	7
TOTAL**	2.4		17.8	20.2	1.7	17.5	19.2	1.0	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-13

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	21.5	12.1	0.50	51.4	3.73	234	69		2.96	11.8
0.5	44.8	25.2	1.06	55.2		233	65			
1.0	46.6	25.3	1.01	54.8		234	66			
1.5	46.5	25.4	0.99	54.6		234	67			
2.0	47.1	25.3	1.00	54.6		233	66			
2.5	47.0	25.3	0.98	53.9		238	65			
3.0	46.3	25.5	0.99	54.0	50.51	231	63		12.5	35.8

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.5	19.7	0.11	0.65	20.1				
1.0	19.8	0.16	0.73	19.6				
1.5	18.6	0.09	0.73	18.6				
2.0	19.6	0.10	0.73	19.2				
2.5	19.2	0.09	0.75	20.3				
3.0	14.2	0.09	0.77	20.3				
Final	18.1	0.15	0.71	19.6	45.6	1.24	139	0.892
% Remain.	45	1.4	63	81	91		45	88

LEACH TEST: D2-13

PRODUCTS:

SUPERNATENT LIQUID:	18.93	kg		
Settled Solids:	2.63	kg		
Solids:	1.21	kg	46.11%	
Liquid:	1.42	kg		
Total Liquid:	20.35	kg	sg:	1.31 g/cc
Volume:	15.51	l		

LEACH TEST: D2-13 **DATE: January 23/85**

SOLUTION:				
NEW SOLUTION:	19.0	kg		
TOTAL SOLUTION:		kg	sg:	1.23
VOLUME:	15.4	l		

NEW SOLUTION:

H_2O:	11.72	kg
$FeCl_3$ GH_2O:	3.63	kg
NaCl:	2.63	kg
$PbCl_2$:	0.24	kg
Conc HCl:	0.55	l
$ZnCl_2$:	0.13	kg
:	0.64	kg

SOLIDS:

Total Concentrate:	-	kg		
Residue:	3.00	kg	From Test:	D1-13
Solids:	1.73	kg	57.6%	
Liquid:	1.27	kg	sg:	1.34
Volume:	0.947	l		

CONDITIONS:

Test Duration:	4.5	hr.
Temperature:	106	°C

NOTES: H_2O inadvertantly added to filtrate through faulty vacuum valve, depressing solution s.g. and increasing yield slightly by approx. 400 g.

MASS BALANCE LEACH TEST: D2-13

(g)	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	64	1066	1130	-	1110	1110	20	2
Fe	341	55	775	1171	325	802	1127	44	4
Zn	314	47	62	423	8	405	413	10	2
Pb	3	26	187	216	2	200	202	14	6
Cu	12.3	1.0	-	13.3	1.0	9.8	10.8	2.5	19
Cl	-	236	3444	3680	-	3490	3490	190	5
S	793	-	-	808	790	-	805	4	0
SO_4^{2-}	-	13	31	-	-	45	-	-	-
Au*	1.55	-	-	1.55	1.58	-	1.58	(0.03)	0
Ag*	242	37	-	279	58	217	275	4	1
H_2O**	-	0.9	13.3	14.2	-	14.3	14.3	(0.1)	0
OTAL**	1.7	1.3	19.0	22.0	1.2	20.4	21.6	0.4	2

* mg

** kg

SOLUTION ASSAYS TEST: D2-13

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	4.0	12.1	0.21	50.2	23.8	223	69	12.3	2.01	0.6
0.5	20.5	12.4	0.44	50.7		219				
1.0	22.9	12.2	0.54	50.8		218				
1.5	23.5	12.3	0.58	50.7		217				
2.0	24.2	12.4	0.61	49.5		221				
2.5	24.8	12.4	0.61	49.7		218				
3.0	25.0	12.5	0.63	52.0		221				
3.5	24.9	12.5	0.61	48.9		217				
4.0	25.7	12.7	0.61	49.6		224				
4.5	26.1	12.9	0.63	51.7	43.0	225	71.5	13.5	2.90	14.0

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final	0.69	0.13	0.08	26.8	65.2	1.69	48.1	1.30
% Remain.	2.5	67	8.1	95	100		24	102

LEACH TEST: D1-15

PRODUCTS:

SUPERNATENT LIQUID: 17.5 kg

SETTLED SOLIDS: 2.60 kg
SOLIDS: 1.54 kg: 59%
LIQUID: 1.06 kg

TOTAL LIQUID: 18.6 kg sg: 1.28
VOLUME: 14.53 l

LEACH TEST: D1-15 DATE: 01/28/85

SOLUTION:
NEW SOLUTION: 18.9 kg
TOTAL SOLUTION: 18.9 kg sg: 1.24
VOLUME: 15.28 l

NEW SOLUTION:
H_2O: 11.7 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.21 kg
$ZnCl_2$:
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS: 2.44 kg
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 1.25 hr
TEMPERATURE: 105°C

NOTES: Concentrate given 10 minute re-grind.

MASS BALANCE LEACH TEST: D1-15

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			1,034	1,034		1,004	1,004	30	3
Fe	421		750	1,171	373	751	1,124	47	4
Zn	695			695	114	330	444	251	36
Pb	214		180	394	1	353	355	39	10
Cu	19.5			19.5	5.9	4.7	10.6	8.9	46
Cl			3,307	3,307		2,888	2,888	419	13
S	872			872	798	30	828	44	5
SO_4^{2-}									
Au*	1.7			1.7	1.9		1.9	(0.2)	
Ag*	532			532	270	322	592	(60)	
H_2O**			13.6	13.6		13.2	13.2	0.4	3
TOTAL**	2.4		18.9	21.3	1.5	18.5	20.0	1.3	6

* mg

** kg

SOLUTION ASSAYS TEST: D1-15

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	0	9.9	0.02	50.7	0	234	70	13.7	0.49	23.2
0.25	22.7	21.6	0.42	50.5		197				
0.50	22.4	21.7	0.40	51.7		199				
0.75	22.5	22.0	0.42	51.0		201				
1.00	22.7	22.2	0.41	51.5		198				
1.25	22.7	24.3	0.32	51.6	50.6	199	69	6.15	6.21	22.1

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	6.5	0.12	0.32	23.0				
0.50	6.6	0.10	0.32	23.0				
0.75	6.2	0.09	0.35	22.8				
1.00	6.1	0.09	0.32	22.9				
1.25	5.8	0.12	0.34	23.5				
Final	7.4	0.09	0.38	24.1	51.7	1.67	175	1.23
% Remain.	16	0.5	30	89	92		51	112

LEACH TEST: D2-15

PRODUCTS:

SUPERNATENT LIQUID: 17.8 kg

SETTLED SOLIDS: 2.76 kg
SOLIDS: 1.34 kg: 49%
LIQUID: 1.42 kg

TOTAL LIQUID: 19.22 kg sg: 1.28
VOLUME: 15.02 l

LEACH TEST: D2-15 DATE: 01/29/85

SOLUTION:
NEW SOLUTION: 19.0 kg
TOTAL SOLUTION: 19.0 kg sg: 1.24
VOLUME: 15.33 l

NEW SOLUTION:
H_2O: 11.72 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$: 0.125 kg
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.60 kg from Test: D1-15
SOLIDS: 1.34 kg: 52%
LIQUID: 1.26 kg sg: 1.28
VOLUME: 0.984 l

CONDITIONS:
TEST DURATION: 2.0 hr
TEMPERATURE: 105-106.5°C

MASS BALANCE LEACH TEST: D2-15

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		57	1,034	1,091		1,056	1,056	35	3
Fe	373	43	750	1,166	378	737	1,115	51	4
Zn	114	19	60	193	13	324	337	(144)	
Pb	1	20	180	201	1	176	177	24	12
Cu	4.7	0.3		5.0	2.0	9.5	11.5	(6.5)	
Cl		164	3,378	3,542		3,358	3,358	184	5
S	798	2		800	874	14	888	(88)	
SO_4^{2-}									
Au*	1.9			1.9	3.0		3.0	(1.1)	
Ag*	270	18		288	88	198	286	2	1
H_2O**		0.8	13.6	14.4		13.6	13.6	0.8	6
TOTAL**	1.5	1.1	19.0	21.6	1.3	19.2	20.5	1.1	5

* mg

** kg

SOLUTION ASSAYS TEST: D2-15

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	4.0	9.6	0	49.5	0	234	71		0.58	2.3
0.25	15.0	10.3	0.29	49.9		212				
0.50	16.9	10.5	0.37	50.8		218				
1.00	18.8	10.5	0.46	50.7		223				
1.50	20.6	10.3	0.63	49.8		218				
2.00	21.6	11.7	0.63	49.8	39.2	223	70		2.75	13.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.25	3.7	0.08	0.27	25.3				
0.50	3.1	0.08	0.24	25.8				
1.00	2.1	0.08	0.23	26.6				
1.50	1.50	0.08	0.18	26.9				
2.00	1.0	0.08	0.18	27.3				
Final	1.0	0.07	0.15	28.2	65.1	1.42	65.4	2.30
% Remain.	11	100	43	101	110		33	100

LEACH TEST: D2-50

PRODUCTS:

SUPERNATENT LIQUID: 4.35 kg

SETTLED SOLIDS: 1.54 kg
SOLIDS: 1.24 kg: 81%
LIQUID: 0.30 kg

TOTAL LIQUID: 4.65 kg sg: 1.26
VOLUME: 3.690 l

LEACH TEST: D2-50 DATE: 01/29/85

SOLUTION: 1.52 kg
NEW SOLUTION: 3.73 kg
TOTAL SOLUTION: 5.25 kg sg: 1.23
VOLUME: 4.28 l

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3\cdot 6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$:
$ZnCl_2$:
Conc HCl: 0.109 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE: 2.76 kg
RESIDUE: 2.76 kg from Test: D2-15
SOLIDS: 1.24 kg: 45%
LIQUID: 1.52 kg sg: 1.28
VOLUME: 1.19 l

CONDITIONS:
TEST DURATION: 3.0 hr
TEMPERATURE: 105°C

NOTES: * Zero value includes slurry. H_2O was held back to wash slurry into reaction vessel - no time zero taken.

+ C.F. D2-51 for representative zero values.

MASS BALANCE LEACH TEST: D2-50

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		78	207	285		270	270	15	5
Fe	378	55	150	583	320	174	494	89	15
Zn	13	24		37	15	37	52	(15)	
Pb	1	13		14	2	13	15	(1)	
Cu	20	0.7		2.7	1.2	1.6	2.8	(0.1)	
Cl		247	654	901		751	751	150	17
S	874	1		875	754	7	761	114	13
SO_4^{2-}									
Au*	3.0			3.0	3.0		3.0		
Ag*	88	15		103	44				
H_2O**		1.0	2.7	3.7		3.4	3.4	0.3	8
TOTAL**	1.3	1.4	3.7	6.4	1.2	4.7	5.9	0.5	8

* mg

** kg

SOLUTION ASSAYS TEST: D2-50

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
+0	*0.1	0	*0.02	48.9	0		71		*0.46	*0.3
*0	7.1	3.6	0.27	47.0	17.7	207			1.49	
0.5	8.1	3.6	0.33	45.5		196				
1.0	8.7	3.8	0.34	47.6		206				
2.0	8.3	3.2	0.37	43.6		181				
3.0	10.1	3.5	0.42	47.1	43.6	203	73		5.78	

* Detection limits.

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.5	1.93	0.07	0.12	27.1				
1.0	1.72	0.07	0.13	26.9				
2.0	1.43	0.07	0.11	27.4				
3.0	1.13	0.06	0.11	27.3				
Final	1.19	0.13	0.10	25.9	61.0	1.39	35.7	2.50
% Remain.	115	100	60	85	86		50	100

LEACH TEST: D1-16 DATE: 01/30/85

SOLUTION:

NEW SOLUTION: 18.87 kg*

TOTAL SOLUTION: 18.87 kg sg: 1.24

VOLUME: 15.21 l

NEW SOLUTION:

H_2O: 11.72 kg

$FeCl_3 \cdot 6H_2O$: 3.63 kg

NaCl: 2.63 kg

$PbCl_2$: 0.24 kg

$ZnCl_2$:

Conc HCl: 0.546 l

: 0.64 kg

SOLIDS:

TOTAL CONCENTRATE: 2.38 kg

RESIDUE:

SOLIDS:

LIQUID:

VOLUME:

CONDITIONS:

TEST DURATION: 1.25 hr

TEMPERATURE: 105-106°C

NOTES: 5371 concentrate given 20 minute re-grind with H_2O.

* 0.430 kg H_2O in concentrate from re-grind.

LEACH TEST: D1-16

PRODUCTS:

SUPERNATENT LIQUID: 18.0 kg

SETTLED SOLIDS: 2.52 kg

SOLIDS: 1.50 kg: 60%

LIQUID: 1.02 kg

TOTAL LIQUID: 19.0 kg sg: 1.29

VOLUME: 14.73 l

MASS BALANCE LEACH TEST: D1-16

(g)	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			1,034	1,034		958	958	76	7
Fe	411		750	1,161	356	745	1,103	58	5
Zn	680			680	274	329	603	77	11
Pb	210		180	390	1	342	343	47	12
Cu	19.1			19.1	13.5	4.1	17.6	1.5	8
Cl			3,307	3,307		3,095	3.095	212	6
S	852			852	791	29	820	32	4
SO_4^{2-}									
Au*	1.6			1.6	1.5		1.5	0.1	6
Ag*	520			520	258	227	485	35	7
H_2O**	0.4		13.6	14.0		13.5	13.5	0.5	7
TOTAL**	2.8		18.9	21.7	1.5	19.0	20.5	1.2	6

* mg

** kg

SOLUTION ASSAYS TEST: D1-16

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0	10.9	0	48.7	0	214	66		0.54	0.2
0.25	22.3	22.4	0.43	50.8		212				
0.50	22.1	22.3	0.41	49.5		212				
0.75	22.3	22.6	0.43	50.5		213				
1.00	22.5	22.2	0.45	50.7		213				
1.25	22.3	23.2	0.28	50.6	45.6	210	65		5.96	15.4

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	16.6	0.09	0.68	24.8				
0.50	17.6	0.09	0.71	25.0				
0.75	17.2	0.08	0.68	23.9				
1.00	17.2	0.08	0.70	23.6				
1.25	18.6	0.13	0.89	23.6				
Final	18.3	0.09	0.90	23.9	52.9	1.22	172	0.994
% Remain.	40	0.5	71	87	93		50	94

LEACH TEST: D2-16

PRODUCTS:

SUPERNATENT LIQUID: 16.1 kg

SETTLED SOLIDS: 2.70 kg
SOLIDS: 1.30 kg: 48.2%
LIQUID: 1.40 kg

TOTAL LIQUID: 17.5 kg sg: 1.27
VOLUME: 13.7 l

LEACH TEST: D2-16 DATE: 01/30/85

SOLUTION:
NEW SOLUTION: 19.0 kg
TOTAL SOLUTION: 19.0 kg sg: 1.25
VOLUME: 15.23 l

NEW SOLUTION:
H_2O: 11.72 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$: 0.13 kg
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.52 kg from Test: D1-16
SOLIDS: 1.49 kg: 59%
LIQUID: 1.03 kg sg: 1.29
VOLUME: 0.80 l

CONDITIONS:
TEST DURATION: 2.0 hr
TEMPERATURE: 105-106.5°C

MASS BALANCE LEACH TEST: D2-16

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		52	1,034	1,086		877	877	209	19
Fe	358	40	750	1,148	393	668	1,061	87	8
Zn	274	18	60	352	17	285	302	50	14
Pb	1	19	180	200	1	164	165	35	18
Cu	13.5	0.2		13.7	2.6	8.4	11.0	2.7	20
Cl		167	3,378	3,545		3,064	3,064	481	14
S	791			792	826		839	(47)	
SO_4^{2-}		5				39			
Au*	1.5			1.5	1.43		1.43	.07	5
Ag*	258	12		270	52	167	219	51	19
H_2O**		0.8	13.6	14.4		12.4	12.4	2.0	14
TOTAL**	1.5	1.0	19.0	21.5	1.3	17.5	18.8	2.7	13

* mg

** kg

SOLUTION ASSAYS TEST: D2-16

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	4.2	10.9	0	48.0	0	217	64	12.9	0.59	0.2
0.25	16.8	12.2	0.33	50.2		226				
0.50	18.4	12.2	0.49	48.4		222				
1.00	19.6	12.4	0.54	48.5		226				
1.50	20.8	12.3	0.60	49.7		214				
2.00	20.8	12.0	0.61	48.7	38.7	224	64	13.4	2.81	12.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.25	5.50	0.07	0.43	25.8				
0.50	3.75	0.06	0.33	26.6				
1.00	2.50	0.06	0.28	26.9				
1.50	2.25	0.06	0.25	26.7				
2.00	7.50	0.06	0.50	25.3				
Final	1.33	0.07	0.20	30.2	63.4	1.37	40.1	1.10
% Remain.	6.2	100	19	110	104		20	95

LEACH TEST: D2-51

PRODUCTS:

SUPERNATENT LIQUID: 4.26 kg

SETTLED SOLIDS: 2.20 kg
SOLIDS: 1.21 kg: 55%
LIQUID: .99 kg

TOTAL LIQUID: 5.24 kg sg: 1.26
VOLUME: 4.16 l

LEACH TEST: D2-51 DATE: 01/31/85

SOLUTION:
NEW SOLUTION: 3.73 kg
TOTAL SOLUTION: 3.73 kg sg: 1.23
VOLUME: 3.04

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3 \cdot 6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$:
$ZnCl_2$:
Conc HCl: 0.109 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.70 kg from Test: D2-16
SOLIDS: 1.79 kg: 66%
LIQUID: 0.91 kg sg: 1.26
VOLUME: 0.722 l

CONDITIONS:
TEST DURATION: 5.0 hr
TEMPERATURE: 105-106°C

MASS BALANCE LEACH TEST: D2-51

(g)	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		70	207	277		284	284	(7)	
Fe	393	54	150	597	363	228	591	6	1
Zn	17	23		40	6	37	43	(3)	
Pb	1	13		14	1	16	17	(3)	
Cu	2.6	0.7		3.3	1.6	1.8	3.4	(0.1)	
Cl		246	654	900		970	970	(70)	
S	826			827	808		818	9	1
SO_4^{2-}		3				30			
Au*	1.43			1.43	1.84		1.84	(.41)	
Ag*	52	13		65	36	45	81	(16)	
H_2O**		1.0	2.7	3.7		3.7	3.7		
TOTAL**	1.3	1.4	3.7	6.4	1.2	5.2	6.4		

* mg

** kg

SOLUTION ASSAYS TEST: D2-51

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0.1	0	0.02	48.9	0	226	71	12.5	0.46	0.3
0.5	8.1	4.0	0.31	53.8		235				
1.0	8.4	4.0	0.35	56.2		237				
2.0	8.9	4.0	0.38	55.9		244				
3.0	8.5	3.7	0.39	53.9		225				
4.0	9.6	4.3	0.44	54.3		253				
5.0	8.9	3.9	0.43	54.6	43.0	232	68	27.8	7.2	10.8

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.5	0.91	0.05	0.18	28.2				
1.0	0.83	0.06	0.18	28.0				
2.0	0.71	0.06	0.17	28.0				
3.0	0.65	0.06	0.15	27.2				
4.0	0.61	0.06	0.14	27.8				
5.0	0.54	0.07	0.14	26.4				
Final	0.54	0.04	0.13	30.0	66.8	1.32	29.9	1.51
% Remain.	35	100	62	92	98		69	100

LEACH TEST: D1-17

PRODUCTS:

SUPERNATENT LIQUID: 16.0 kg

SETTLED SOLIDS: 2.92 kg

SOLIDS: 1.36 kg: 47%

LIQUID: 1.56 kg

TOTAL LIQUID: 17.56 kg sg: 1.35

VOLUME: 13.01 l

LEACH TEST: D1-17 DATE: 01/31/85

SOLUTION: 16.2 kg

NEW SOLUTION: 1.0 kg

TOTAL SOLUTION: 17.2 kg sg: 1.29

VOLUME: 13.37 l

NEW SOLUTION:

H_2O: 1.0 kg

$FeCl_3 \cdot 6H_2O$:

NaCl:

$PbCl_2$:

$ZnCl_2$:

Conc HCl:

:

SOLIDS:

TOTAL CONCENTRATE: 2.44 kg

RESIDUE:

SOLIDS: 2.44 kg

*LIQUID: 0.19 kg sg: H_2O

*VOLUME: 0.19 l

CONDITIONS:

TEST DURATION: 1.25 hr

TEMPERATURE: 105-106.5°C

NOTES: * 5371 concentrate reground with H_2O for 20 min.
so it contains 190 g of H_2O

MASS BALANCE LEACH TEST: D1-17

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLUTION	TOTAL	SOLIDS	SOLUTION	TOTAL		
Na			896	896		860	860	36	4
Fe	421		691	1,112	311	707	1,018	94	8
Zn	695		267	962	230	585	815	147	15
Pb	214		159	373	1	327	328	45	12
Cu	19.5		8.8	28.3	9.7	13.4	23.1	5.2	18
Cl			3,376	3,376		3,181	3,181	196	6
S	872		13	885	723	37	760	124	14
SO_4^{2-}									
Au*	1.7			1.7	1.5		1.5	0.2	12
Ag*	532		171	703	223	380	603	100	14
H_2O**	0.2		11.8	12.0		11.8	11.8	0.2	2
TOTAL**	2.6		17.2	19.8	1.4	17.5	18.9	0.9	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-17

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	20.0	11.9	0.66	51.7	0	253	67		2.92	12.8
0.25	46.6	23.8	1.26	54.4		254				
0.50	44.8	24.0	1.31	54.5		249				
0.75				54.4						
1.00	44.3	22.4	1.19	54.2		240				
1.25	44.9	25.1	1.03	54.3	48.5	244	66		8.51	29.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	14.3	0.10	0.40	24.2				
0.50	14.5	0.07	0.40	23.7				
0.75	15.0	0.09	0.43	23.2				
1.00	14.5	0.08	0.43	23.9				
2.00	16.8	0.12	0.75	22.1				
Final	16.9	0.08	0.71	22.9	53.1	1.42	164	1.09
% Remain.	33	0.4	50	74	83		42	88

LEACH TEST: D1-18

PRODUCTS:

SUPERNATENT LIQUID: 17.5 kg

SETTLED SOLIDS: 2.41 kg
SOLIDS: 1.52 kg: 63%
LIQUID: 0.89 kg

TOTAL LIQUID: 18.39 kg sg: 1.30
VOLUME: 14.1 l

LEACH TEST: D1-18 DATE: 02/01/85

SOLUTION:
NEW SOLUTION: 18.4 kg
TOTAL SOLUTION: 18.4 kg sg: 1.25
VOLUME: 14.7

NEW SOLUTION:
H_2O: 11.3 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$:
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE: 2.43 kg
RESIDUE:
SOLIDS: 2.43 kg
LIQUID: 0.45 kg sg: H_2O
VOLUME: 0.45 l

CONDITIONS:
TEST DURATION: 1.25 hr
TEMPERATURE: 105-106°C

NOTES: Concentrate washed with Na_2S Solution.

MASS BALANCE LEACH TEST: D1-18

	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			1,034	1,034		972	972	62	6
Fe	421		750	1,171	335	757	1,092	79	7
Zn	695		-	695	295	324	619	76	11
Pb	214		180	394	2	386	388	6	2
Cu	19.4			19.4	13.1	4.2	17.3	2.1	11
Cl			3,307	3,307		2,984	2,984	323	10
S	868			868	747	26	773	95	11
SO_4^{2-}									
Au*	1.7			1.7	1.5		1.5	0.2	12
Ag*	530			530	266	240	506	24	5
H_2O**			13.6	13.6		12.9	12.9	0.7	5
TOTAL**	2,4		18.9	21.3	1.5	18.4	19.9	1.4	7

* mg

** kg

SOLUTION ASSAYS TEST: D1-18

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0	12.0	0.03	51.3	0	230	68	14.0	0.44	0.5
0.25	22.5	23.4	0.53	53.3		212				
0.50	23.2	28.5	0.51	52.9		232				
0.75	23.1	24.4	0.51	53.6		251				
1.00	23.2	30	0.52	53.9		225				
1.25	23.0	27.4	0.30	53.8	50.8	212	69	6.8	5.54	17.0

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	17.4	0.14	0.59	22.6				
0.50	17.2	0.13	0.62	22.1				
0.75	17.6	0.11	0.60	22.8				
1.00	17.6	0.11	0.61	22.3				
1.25	16.5	0.10	0.72	22.3				
Final	19.4	0.13	0.86	22.1	49.2	1.43	175	0.994
% Remain	42	0.9	68	80	86		50	88

LEACH TEST: D2-18

PRODUCTS:

SUPERNATENT LIQUID: 17.7 kg

SETTLED SOLIDS: 2.28 kg
SOLIDS: 1.17 kg: 51%
LIQUID: 1.11 kg

TOTAL LIQUID: 18.8 kg sg: 1.29
VOLUME: 14.58 l

LEACH TEST: D2-18 DATE: 02/04/85

SOLUTION:
NEW SOLUTION: 19.0 kg
TOTAL SOLUTION: 19.0 kg sg: 1.25
VOLUME: 15.2 l

NEW SOLUTION:
H_2O: 11.7 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$: 0.13 kg
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.32 kg from Test: D1-18
SOLIDS: 1.52 kg
LIQUID: 0.80 kg sg: 1.30
VOLUME: 0.615 l

CONDITIONS:
TEST DURATION: 2.0 hr
TEMPERATURE: 105-106°C

MASS BALANCE LEACH TEST: D2-18

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		45	1,034	1,079		1,139	1,139	(60)	
Fe	322	35	750	1,107	341	729	1,070	37	3
Zn	283	15	60	358	35	302	337	21	6
Pb	2	18	180	200	1	194	195	5	3
Cu	12.6	0.2		12.8	2.7	9.5	12.2	0.6	5
Cl		139	3,378	3,517		3,312	3,312	205	6
S	718	1		719	760	13	773	(54)	
SO_4^{2-}									
Au*	1.5			1.5	1.5		1.5		
Ag*	256	11		267	52	193	245	22	8
H_2O**		0.6	13.6	14.2		13.1	13.1	1.1	8
TOTAL**	1.5	0.9	19.0	21.4	1.2	18.8	20.0	1.4	7

* mg

** kg

SOLUTION ASSAYS TEST: D2-18

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	3.9	11.5	0.01	50.8		282	75	13.5	0.44	0.4
0.25	14.8	13.4	0.42	51.4		229				
0.50	16.8	13.6	0.49	50.1		229				
1.00	18.3	15.5	0.53	51.6		227				
1.50	19.6	12.8	0.59	49.2		224				
2.00	20.7	13.3	0.65	49.9	43.0	227	78	15.7	2.65	13.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	8.75	0.09	0.57	27.4				
0.50	8.25	0.08	0.52	27.3				
1.00	7.00	0.09	0.42	28.0				
1.50	4.25	0.08	0.35	27.7				
2.00	3.25	0.08	0.19	27.9				
Final	3.00	0.09	0.23	29.0	64.8	1.80	44.1	1.36
% Remain.	12	50	21	106	106		20	100

LEACH TEST: D2-52

PRODUCTS:

SUPERNATENT LIQUID: 3.66 kg

SETTLED SOLIDS: 1.77 kg
SOLIDS: 0.98 kg: 55%
LIQUID: 0.79 kg

TOTAL LIQUID: 4.45 kg sg: 1.24
VOLUME: 3.59 l

LEACH TEST: D2-52 DATE: 02/08/85

SOLUTION:
NEW SOLUTION: 3.73 kg
TOTAL SOLUTION: 3.73 kg sg: 1.23
VOLUME: 3.031 l

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3 \cdot 6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$:
$ZnCl_2$:
Conc HCl: 0.109 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.28 kg from Test: D2-18
SOLIDS: 1.17 kg: 51%
LIQUID: 1.11 kg sg: 1.29
VOLUME: 0.860 l

CONDITIONS:
TEST DURATION: 5.0 hr
TEMPERATURE: 104-105.5°C

NOTES: Problems with using ordinary paper filter - too weak to stand hot solution.

MASS BALANCE LEACH TEST: D2-52

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		67	207	274		241	241	33	12
Fe	341	43	150	534	283	186	469	65	12
Zn	35	18		53	8	38	46	7	13
Pb	1	11		12		13	13	(1)	
Cu	27	0.6		3.3	1.4	1.3	2.7	0.6	18
Cl		196	654	850		776	776	74	9
S	760			761	645		653	108	14
SO_4^{2-}		2				23			
Au*	1.5			1.5	1.37		1.37	0.13	9
Ag*	52	11		63	34	52	86	(23)	
H_2O**		0.8	2.7	3.5		3.2	3.2	0.3	9
TOTAL**	1.2	1.1	3.7	6.0	1.0	4.5	5.5	0.5	8

* mg

** kg

SOLUTION ASSAYS TEST: D2-52

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0			0.02	46.6		211	67		0.44	<0.4
0.50	8.4	3.9	0.23	53.4		229				
1.00	8.4	3.7	0.25	50.7		280				
2.00	9.0	3.6	0.26	52.1		213				
3.00	9.7	3.5	0.29	50.7		209				
4.00	10.5	3.8	0.31	52.9		219				
5.00	10.7	3.7	0.35	51.9	46.6	216	67		6.36	14.4

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.50	2.09	0.08	0.22	28.8				
1.00	2.01	0.07	0.21	28.0				
2.00	1.66	0.07	0.19	28.0				
3.00	1.42	0.08	0.18	22.8				
4.00	1.16	0.07	0.17	27.9				
5.00	0.94	0.06	0.20	27.7				
Final	0.84	0.04	0.14	29.0	66.0	1.61	35.1	1.41
% Remain.	23	0	52	83	86		65	91

LEACH TEST: D1-19

PRODUCTS:

SUPERNATENT LIQUID: 14.7 kg

SETTLED SOLIDS: 2.65 kg
SOLIDS: 1.55 kg: 58%
LIQUID: 1.1 kg

TOTAL LIQUID: 15.8 kg sg: 1.38
VOLUME: 11.45 l

LEACH TEST: D1-19 DATE: 02/05/85

SOLUTION: 16.8 kg from Test: D3-13 (D2-18)
NEW SOLUTION:
TOTAL SOLUTION: 16.8 kg sg: 1.30
VOLUME: 12.9 l

NEW SOLUTION:
H_2O:
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.36 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 1.25 hr
TEMPERATURE: 105-107°C

NOTES: Concentrate washed with Na_2S Solution.

MASS BALANCE LEACH TEST: D1-19

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			994	994		908	908	86	9
Fe	408		693	1,101	372	735	1,107	(6)	0
Zn	672		294	966	307	588	895	71	7
Pb	207		186	393	1	372	373	20	5
Cu	18.9		7.1	26.0	9.9	16.4	26.3	(0.3)	
Cl			3,600	3,606		3,299	3,299	307	9
S	843		13	856	786	44	830	26	3
SO_4^{2-}									
Au*	1.6			1.6	1.5		1.5	0.1	6
Ag*	515		147	662	192	434	626	36	5
H_2O**			11.0	11.0		9.8	9.8	1.2	11
TOTAL**	2.4		16.8	19.2	1.5	15.8	17.3	1.9	10

* mg

** kg

SOLUTION ASSAYS TEST: D1-19

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	22.8	14.4	0.55	53.7	6.2	279	77	16.0	2.92	11.4
0.25	49.8	31.8	1.43	60.5		303				
0.50	49.9	31.4	1.40	61.2		278				
0.75	50.1	31.3	1.42	63.2		283				
1.00	50.6	32.1	1.40	63.0		284				
1.25	51.2	32.4	1.43	63.9	61.4	287	79	13.9	11.36	37.8

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.25	20.1	0.12	0.60	25.1				
0.50	20.1	0.11	0.59	26.0				
0.75	19	0.10	0.62	24.9				
1.00	20.6	0.10	0.56	24.9				
1.25	19.4	0.09	0.65	25.0				
Final	19.8	0.09	0.64	24.1	50.8	1.32	142	1.10
% Remain.	46	0.5	52	91	93		37	94

LEACH TEST: D1-20

PRODUCTS:

SUPERNATENT LIQUID: 17.6 kg

SETTLED SOLIDS: 2.68 kg
SOLIDS: 1.53 kg: 57%
LIQUID: 1.15 kg

TOTAL LIQUID: 18.8 kg sg: 1.29
VOLUME: 14.57 l

LEACH TEST: D1-20 DATE: 02/06/85

SOLUTION:
NEW SOLUTION: 18.9 kg
TOTAL SOLUTION: 18.9 kg sg: 1.25
VOLUME: 15.13 l

NEW SOLUTION:
H_2O: 11.7 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$:
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 1.25 hr
TEMPERATURE: 105-106°C

MASS BALANCE LEACH TEST: D1-20

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			1,034	1,034		957	957	77	7
Fe	421		750	1,171	366	709	1,075	96	8
Zn	695			695	286	342	628	67	10
Pb	214		180	394	2	358	360	34	9
Cu	19.5			19.5	11.3	5.2	16.5	3.0	15
Cl			3,307	3,307		3,080	3,080	227	7
S	871			871	780	45	825	46	5
SO_4^{2-}									
Au*	1.7			1.7	1.5		1.5	0.2	12
Ag*	532			532	212	263	475	57	11
H_2O**			13.6	13.6		13.2	13.2	0.3	2
TOTAL**	2.4		18.9	21.3	1.5	18.7	20.2	1.1	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-20

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0.3	11.3	0.05	47.1		208	66		0.44	<0.4
0.25	24.1	25.5	0.38	48.2		216				
0.50	24.2	25.1	0.39	47.6		218				
0.75	24.0	24.7	0.33	48.7		215				
1.00	24.3	25.6	0.36	48.6		221				
1.25	23.6	24.7	0.36	48.9	49.2	212	66		9.22	18.1

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	24.2	0.15	0.85	30.0				
0.50	18.4	0.11	0.70	26.3				
0.75	18.9	0.09	0.70	25.3				
1.00	18.7	0.09	0.71	24.5				
1.25	18.6	0.09	0.71	24.7				
Final	18.7	0.09	0.74	23.9	50.9	1.24	138	0.994
% Remain.	41	0.9	58	87	90		40	88

LEACH TEST: D2-20

PRODUCTS:

SUPERNATENT LIQUID: 17.9 kg

SETTLED SOLIDS: 2.22 kg
SOLIDS: 1.09 kg: 49%
LIQUID: 2.04 kg

TOTAL LIQUID: 19.9 kg sg: 1.28
VOLUME: 15.55 l

LEACH TEST: D2-20 DATE: February 6, 1985

SOLUTION:
NEW SOLUTION: 18.8 kg
TOTAL SOLUTION: 18.8 kg sg: 1.25
VOLUME: 14.97 l

NEW SOLUTION:
H_2O: 11.5 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$: 0.13 kg
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.68 kg from Test: D1-20
SOLIDS: 1.53 kg: 57%
LIQUID: 1.15 kg sg: 1.29
VOLUME: 14.57 l

CONDITIONS:
TEST DURATION: 2.0 hr
TEMPERATURE: 106°C

NOTES: Filter cloth retained = 16.5 g of solids.

MASS BALANCE LEACH TEST: D2-20

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		59	1,034	1,093		1,012	1,012	81	7
Fe	366	44	750	1,160	311	701	1,012	148	13
Zn	286	21	60	367	20	309	329	38	10
Pb	2	22	180	204	1	183	184	20	10
Cu	11.3	0.3		11.6	2.3	6.4	8.7	2.9	25
Cl		189	3,378	3,567		3,252	3,252	315	9
S	780	3		783	703	13	716	67	9
SO_4^{2-}									
Au*	1.5			1.5	1.6		1.6	(0.1)	
Ag*	212	16		228	37	133	170	58	25
H_2O**		0.8	13.4	14.2		13.5	13.5	0.7	5
TOTAL**	1.5	1.1	18.8	21.4	1.1	19.0	20.1	1.3	6

* mg

** kg

SOLUTION ASSAYS TEST: D2-20

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	4.2	11.6	0.03	49.4		226	70		0.44	<0.4
0.25	16.6	12.6	0.24	46.6		216				
0.50	18.2	12.4	0.29	46.9		219				
1.00	19.8	13.0	0.37	46.4		226				
1.50	20.7	12.8	0.41	47.3		226				
2.00	20.8	12.3	0.43	47.1	43.9	219	68		2.58	8.9

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.25	6.60	0.09	0.51	27.8				
0.50	6.08	0.08	0.45	28.7				
1.00	4.79	0.08	0.34	28.0				
1.50	3.34	0.08	0.26	28.7				
2.00	2.42	0.10	0.20	29.2				
Final	1.82	0.09	0.21	28.7	65.0	1.54	34.2	1.51
% Remain.	7.0	50	20	85	90		17	107

LEACH TEST: D2-53

PRODUCTS:

SUPERNATENT LIQUID: 3.74 kg

WASHED ~~SETTLED~~ SOLIDS: 1.34 kg

SOLIDS: 0.99 kg

LIQUID: 0.34 kg

TOTAL LIQUID: 4.09 kg sg: 1.26

VOLUME: 3.246 l

LEACH TEST: D2-53 DATE: 02/07/85

SOLUTION:

NEW SOLUTION: 3.73 kg

TOTAL SOLUTION: 3.73 kg sg: 1.23

VOLUME: 3.041 l

NEW SOLUTION:

H_2O: 2.34 kg

$FeCl_3 \cdot 6H_2O$: 0.73 kg

NaCl: 0.53 kg

$PbCl_2$:

$ZnCl_2$:

Conc HCl: 0.109 l

: 0.13 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.22 kg from Test: D2-20

SOLIDS: 1.08 kg: 49%

LIQUID: 1.14 kg sg: 1.28

VOLUME: 0.891

CONDITIONS:

TEST DURATION: 6.0 hr

TEMPERATURE: 105-106°C

NOTES: Weight of settled solids not recorded.

MASS BALANCE LEACH TEST: D2-53

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		61	207	268		237	237	31	12
Fe	311	42	150	503	287	177	464	39	8
Zn	20	18		38	5	32	37	1	3
Pb	1	11		12	1	12	13	(1)	
Cu	2.3	0.4		2.7	1.5	0.8	2.3	0.4	15
Cl		195	654	849		762	762	87	10
S	703			704	653		661	43	6
SO_4^{2-}		2				25			
Au*	1.6			1.6	1.13		1.13	0.47	29
Ag*	37	8		45	25	28	53	(8)	
H_2O**		0.8	2.7	3.5		2.8	2.8	0.7	20
TOTAL**	1.1	1.1	3.7	5.9	1.0	4.1	5.1	0.8	14

* mg

** kg

SOLUTION ASSAYS TEST: D2-53

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0		0.2	0.02	49.1		210	69	15.7	0.48	<0.4
0.5	7.6	3.8	0.19	51.3		220				
1.0	8.1	3.4	0.20	52.4		217				
2.0	8.5	3.3	0.25	52.5		217				
3.0	8.8	3.4	0.25	50.8		217				
4.0	9.3	3.5	0.30	52.2		217				
5.0	9.3	3.3	0.28	51.9		210				
6.0	19.5	7.1	0.48	54.6	49.6	234	73	23.9	7.83	8.6

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.5	1.46	0.07	0.14	29.0				
1.0	1.24	0.06	0.13	28.8				
2.0	1.03	0.05	0.12	28.3				
3.0	0.89	0.06	0.12	28.0				
4.0	0.74	0.05	0.11	28.0				
5.0	0.62	0.05	0.10	28.0				
6.0	0.62	0.06	0.13	28.0				
Final	0.52	0.07	0.15	29.1	66.1	1.44	28.6	1.30
% Remain.	25	100	65	92	93		76	71

LEACH TEST: D1-21

PRODUCTS:

SUPERNATENT LIQUID: 16.7 kg

SETTLED SOLIDS: 2.42 kg
SOLIDS: 1.47 kg: 60.8%
LIQUID: 0.95 kg

TOTAL LIQUID: 17.7 kg sg: 1.342
VOLUME: 13.2 l

LEACH TEST: D1-21 DATE: 02/07/85

SOLUTION: 16.8 kg from Test: D3-14
NEW SOLUTION: 1.0 kg
TOTAL SOLUTION: 17.8 kg sg: 1.295
VOLUME: 13.7 l

NEW SOLUTION:
H_2O: 1.0 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.42 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 1.25 hr
TEMPERATURE: 106°C

NOTES: Lost 20 g conc. at start

MASS BALANCE LEACH TEST: D1-21

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na			991	991		922	922	69	7
Fe	411		727	1,138	357	733	1,090	45	4
Zn	688		304	992	277	642	919	73	7
Pb	212		175	387	2	238	240	147	38
Cu	19.3		7.0	26.3	9.7	16.3	26.0	0.3	1
Cl			3,538	3,538		3,316	3,316	222	6
S	862		12	874	749	54	803	71	8
SO_4^{2-}									
Au*	1.7			1.7	1.4		1.4	0.3	18
Ag*	526		122	648	165	407	572	76	12
H_2O**			12.1	12.1		11.8	11.8	0.3	2
TOTAL**	2.4		17.8	20.2	1.5	17.7	19.2	1.0	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-21

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	22.1	12.7	0.51	52.8	1.63	257	72	16.9	2.64	8.8
0.25	48.7	28.8	1.34	56.6		260				
0.50	47.5	27.4	1.31	57.6		255				
0.75	48.1	28.8	1.31	57.6		257				
1.00	49.0	28.8	1.37	57.9		260				
1.25	48.7	18.1	1.24	55.7	53.0	252	70	11.1	12.2	30.9

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.25	19.3	0.14	0.68	23.7				
0.50	18.5	0.12	0.56	24.0				
0.75	18.7	0.11	0.59	24.5				
1.00	18.6	0.12	0.61	23.9				
1.25	17.6		0.61	22.4				
Final	18.9	0.12	0.66	24.3	51.0	1.62	128	1.09
% Remain	40	0.9	50	87	87		31	82

LEACH TEST: D1-22

PRODUCTS:

SUPERNATENT LIQUID:	17.5 kg		
SETTLED SOLIDS:	2.49 kg		
SOLIDS:	1.52 kg:	61%	
LIQUID:	0.97 kg		
TOTAL LIQUID:	18.5 kg	sg:	1.29
VOLUME:	14.32 l		

LEACH TEST: D1-22 DATE: 02/12/85

SOLUTION:

NEW SOLUTION:	18.7 kg		
TOTAL SOLUTION:	18.7 kg	sg:	1.24
VOLUME:	15.26 l		

NEW SOLUTION:

H_2O:	11.72 kg
$FeCl_3 \cdot 6H_2O$:	3.63 kg
NaCl:	2.63 kg
$PbCl_2$:	0.24 kg
$ZnCl_2$:	
Conc HCl:	0.546 l
:	0.64 kg

SOLIDS:

TOTAL CONCENTRATE:	2.43 kg
RESIDUE:	
SOLIDS:	
LIQUID:	
VOLUME:	

CONDITIONS:

TEST DURATION:	0.75 hr
TEMPERATURE:	102-106°C

MASS BALANCE LEACH TEST: D1-22

	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
(g)	SOLIDS	SLURRY LIQUID	SOLUTION	TOTAL	SOLIDS	SOLUTION	TOTAL		
Na			1,034	1,034		989	989	45	4
Fe	421		750	1,171	379	746	1,125	46	4
Zn	695			695	266	353	619	76	11
Pb	214		180	394	3	350	355	41	10
Cu	19.5			19.5	12.4	3.7	16.1	3.4	17
Cl			3,307	3,307		3,206	3,206	101	3
S	871			871	777		823	48	6
SO_4^{2-}						138			
Au*	1.66			1.66	2.14		2.14	(.48)	
Ag*	532			532	254	240	494	38	7
H_2O**			13.6	13.6		11.7	11.7	1.9	14
OTAL**	2.4		18.9	21.3	1.5	17.5	19.0	2.3	11

* mg

** kg

SOLUTION ASSAYS TEST: D1-22

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0.1	11.8	0.07	50.9	0	222	68		0.27	0.4
0.16	24.7	25.8	0.38	53.2		227				
0.33	25.5	25.3	0.43	56.1		228				
0.50	34.2	35.4	0.61	63.3		287				
0.75	24.6	24.4	0.26	52.0	48.0	224	69		9.62	16.7

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.16	18.0	0.17	0.72	25.5				
0.33	16.8	0.16	0.73	25.3				
0.50	16.9	0.25	0.71	26.0				
0.75	18.5	0.13	0.75	25.5				
Final	17.6	0.17	0.82	25.0	51.3	1.13	168	1.41
% Remain.	38	1.4	64	90	89		48	100

LEACH TEST: D2-22

PRODUCTS:

SUPERNATENT LIQUID: 18.1 kg

SETTLED SOLIDS: 2.39 kg
SOLIDS: 1.18 kg: 49%
LIQUID: 1.21 kg

TOTAL LIQUID: 1.93 kg sg: 1.26
VOLUME: 15.33 l

LEACH TEST: D2-22 DATE: 02/14/85

SOLUTION:
NEW SOLUTION: 19.0 kg
TOTAL SOLUTION: 19.0 kg sg: 1.24
VOLUME: 15.28 l

NEW SOLUTION:
H_2O: 11.7 kg
$FeCl_3 \cdot 6H_2O$: 3.63 kg
NaCl: 2.63 kg
$PbCl_2$: 0.24 kg
$ZnCl_2$: 0.13 kg
Conc HCl: 0.546 l
: 0.64 kg

SOLIDS:

TOTAL CONCENTRATE:
RESIDUE: 2.63 kg from Test: D1-22
SOLIDS: 1.18 kg: 45%
LIQUID: 1.45 kg sg: 1.24
VOLUME: 1.169 l

CONDITIONS:
TEST DURATION: 1.0 hr
TEMPERATURE: 106°C

MASS BALANCE LEACH TEST: D2-22

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL inc. wash		
Na		49	1,039	1,088		1,040	1,040	48	4
Fe	362	37	735	1,134	335	742	1,077	57	5
Zn	252	18	60	330	76	254	330	0	
Pb	2	17	171	190	1	202	203	(13)	
Cu	11.8	0.2		12.0	5.2	5.7	10.9	1.1	9
Cl		160	3,237	3,397		3,235	3,235	62	2
S	736			738	[illegible]		761	(23)	
SO_4^{2-}		7				95			
Au*	2.02			2.02	1.67		1.67	0.35	17
Ag*	241	12		253	98	24	122	131	52
H_2O**		0.6	13.7	14.3		13.7	13.7	0.6	4
OTAL**	1.4	0.9	19.0	21.3	1.2	19.3	20.5	0.8	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-22

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	3.9	11.2	0	48.1	44.9	212	68	12.4		
1.0	16.6	13.2	0.37	32.0	48.5	212	68	27.6		

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
1.0	6.4	0.09	0.44	28.3	61.6		82.6	1.41
% Remain.	30	50	44	93	99		41	83

LEACH TEST: D2-55 DATE: 02/14/85

SOLUTION:

NEW SOLUTION: 3.73 kg

TOTAL SOLUTION: 3.73 kg sg: 1.23

VOLUME: 3.03 l

NEW SOLUTION:

H_2O: 2.34 kg

$FeCl_3 \cdot 6H_2O$: 0.73 kg

NaCl: 0.53 kg

$PbCl_2$:

$ZnCl_2$:

Conc HCl: 0.11 l

: 0.13 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.28 kg from Test: D2-22

SOLIDS: 1.13 kg: 49.5%

LIQUID: 1.15 kg sg: 1.26

VOLUME: 0.91 l

CONDITIONS:

TEST DURATION: 3.0 hr

TEMPERATURE: 105-106.5°C

LEACH TEST: D2-55

PRODUCTS:

SUPERNATENT LIQUID: 3.08 kg

SETTLED SOLIDS: 2.63 kg: 39.1%

SOLIDS: 1.03 kg

LIQUID: 1.60 kg

TOTAL LIQUID: 4.68 kg sg: 1.26

VOLUME: 3.72 l

SOLUTION ASSAYS TEST: D2-55

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	0	0.2	0	48.0	0	228	67	12.8	0.75	7.9
.5	10.2	3.2	0.33	49.9		210				
1.0	11.9	3.2	0.37	49.1		206				
2.0	15.1	3.0	0.55	50.2		203				
3.0	16.5	3.1	0.64	49.2	44.9	206	69	12.2	4.30	9.0

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
.5	4.7	0.08	0.40	28.2				
1.0	4.4	0.08	0.37	27.6				
2.0	3.2	0.08	0.35	28.1				
3.0	2.7	0.08	0.30	27.7				
Final	3.0	0.09	0.30	28.0	65.3	1.57	54.7	1.51
% Remain.	42	100	60	90	97		60	97

MASS BALANCE LEACH TEST: D2-55

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		62	207	269		257	257	12	4
Fe	320	45	150	515	288	183	471	44	9
Zn	73	15		88	31	61	92	(4)	
Pb	1	12		13	1	12	13	0	0
Cu	5.0	0.3		5.3	3.0	2.4	5.4	(0.1)	
Cl		194	654	848		766	766	82	10
S	696			698	673		678	20	3
SO_4^{2-}		6				16			
Au*	1.60			1.60	1.55		1.55	0.05	3
Ag*	94	1		95	56	33	89	6	6
H_2O**		0.8	2.7	3.5		3.4	3.4	0.1	3
TOTAL**	1.1	1.2	3.7	6.0	1.0	4.7	5.7	0.3	5

* mg

** kg

LEACH TEST: D1-23 DATE: 02/18/85

SOLUTION: 17.0 kg from Test: D3-16
NEW SOLUTION:
TOTAL SOLUTION: 17.0 kg sg: 1.302
VOLUME: 13.09 l

NEW SOLUTION:

H_2O:
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:

TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:

TEST DURATION: 0.75 hr
TEMPERATURE: 98-100°C

NOTES:
1) Add 90% Concentrate 0 hr
2) Add 10% Concentrate 0.5 hr
3) End run 0.75 hr

LEACH TEST: D1-23

PRODUCTS:

SUPERNATENT LIQUID: 15.9 kg

SETTLED SOLIDS: 2.63 kg
SOLIDS: 1.58 kg: 60%
LIQUID: 1.05 kg

TOTAL LIQUID: 17.0 kg sg: 1.36
VOLUME: 12.52 l

MASS BALANCE LEACH TEST: D1-23

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			942	942		1,007	1,007	(65)	
Fe	421		758	1,179	408	768	1,176	3	0
Zn	695		249	944	297	624	921	23	2
Pb	214		171	385	2	399	401	(16)	
Cu	19.5		5.9	25.4	11.8	14.0	25.8	(0.4)	
Cl			3,535	3,535		3,422	3,422	113	3
S	872			885	827		880	5	1
SO_4^{2-}			39			158			
Au*	1.67			1.67	2.06		2.06	(0.39)	
Ag*	532		154	686	234	483	717	(31)	
H_2O**			11.3	11.3		10.6	10.6	0.7	6
TOTAL**	2.4		17.0	19.4	1.6	17.0	18.6	0.8	4

* mg

** kg

SOLUTION ASSAYS TEST: D1-23

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	19.0	13.0	0.45	57.9	<0.1	270	72	20.6	2.97	11.4
0.75	49.9	31.9	1.12	61.4	56.3	273	80.5	12.9	12.6	38.6

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.0								
0.75	25.75	0.12	0.745	25.8	52.2		148	1.30
% Remain	43	0.9	61	97	95		44	123

LEACH TEST: D2-23

PRODUCTS:

SUPERNATENT LIQUID: 18.0 kg

SETTLED SOLIDS: 2.58 kg
SOLIDS: 1.18 kg: 46%
LIQUID: 1.4 kg

TOTAL LIQUID: 19.4 kg sg: 1.29 g/ml
VOLUME: 15.04 l

LEACH TEST: D2-23 DATE: 02/19/85

SOLUTION: 3.1 kg From = D2-55
NEW SOLUTION: 15.9 kg
TOTAL SOLUTION: 19.0 kg sg: 1.26 g/ml
VOLUME: 15.1 l

NEW SOLUTION:

H_2O: 9.79 kg
$FeCl_3 \cdot 6H_2O$: 3.03 kg
NaCl: 2.20 kg
$PbCl_2$: 0.20 kg
$ZnCl_2$: 0.10 kg
Conc HCl: 0.456 l
: 0.64 kg

SOLIDS:

TOTAL CONCENTRATE:
RESIDUE: 2.44 kg from Test: D1-23
SOLIDS: 1.12 kg: 60%
LIQUID: 1.32 kg sg: 1.29
VOLUME: 1.023 l

CONDITIONS:

TEST DURATION: 1.5 hr
TEMPERATURE: 107°C

MASS BALANCE LEACH TEST: D2-23

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		57	1,091	1,148		1,105	1,105	43	4
Fe	379	44	734	1,157	347	764	1,111	46	4
Zn	276	36	104	416	46	363	415	1	
Pb	2	23	179	204	1	209	213	(9)	
Cu	11.0	0.8	2.3	14.1	2.9	8.0	10.9	3.2	23
Cl		195	3,435	3,630		3,445	3,445	185	5
S	768			777	760		775	2	
SO_4^{2-}		9	18			45			
Au*	1.91			1.91	1.54		1.54	.37	19
Ag*	217	28	27	272	85	166	251	21	8
H_2O**		0.6	13.4	14.0		13.4	13.4	0.6	4
TOTAL**	2.4	1.0	19.0	22.4	1.2	19.4	20.6	1.8	8

* mg

** kg

SOLUTION ASSAYS TEST: D2-23

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	6.9	11.9	0.15	48.3	6.00	228	72.5	14.3	0.27	0.4
1.5	24.2	13.9	0.53	50.9	43.7	229	73.5	16.2	2.97	11.0

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
1.5	3.85	0.08	0.25	15.1	64.1		71.7	1.30
% Remain.	17	50	26	92	99		39	81

LEACH TEST: D2-56

PRODUCTS:

SUPERNATENT LIQUID: 4.18 kg

SETTLED SOLIDS: 1.81 kg:
SOLIDS: 1.08 kg 59.6%
LIQUID: 0.73 kg

TOTAL LIQUID: 4.91 kg sg: 1.274
VOLUME: 3.85 l

LEACH TEST: D2-56 DATE: 02/20/85

SOLUTION:
NEW SOLUTION: 3.81 kg
TOTAL SOLUTION: 3.81 kg sg: 1.25
VOLUME: 3.05 l

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3 \cdot 6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$: 0.05 kg
$ZnCl_2$: 0.03 kg
Conc HCl: 0.11 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.46 kg from Test: D2-23
SOLIDS: 1.13 kg: 46.0%
LIQUID: 1.33 kg sg: 1.29
VOLUME: 1.03 l

CONDITIONS:
TEST DURATION: 5.0 hr
TEMPERATURE: 106°C

MASS BALANCE LEACH TEST: D2-56

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		76	204	280		254	254	26	9
Fe	331	52	154	537	310	195	505	32	6
Zn	44	25	12	81	13	65	78	3	4
Pb	1	14	34	49	1	46	47	2	4
Cu	2.8	0.5		3.3	1.6	1.3	2.9	0.4	12
Cl		237	677	914		869	869	45	5
S	725			726	699		706	20	3
SO_4^{2-}		3				22			
Au*	1.47			1.47	1.40		1.40	0.07	5
Ag*	81	11		92	45	54	99	(7)	
H_2O**		0.9	2.7	3.6		3.5	3.5	0.1	3
TOTAL**	1.1	1.3	3.8	6.2	1.1	4.9	6.0	0.2	3

* mg

** kg

SOLUTION ASSAYS TEST: D2-56

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0,0	3.8	11.2	0	50.6	0	222	67	14.2	0.69	0
5.0	17.0	11.9	0.35	54.9	51.3	226	66	23.3	5.76	14.[illegible]

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final	1.21	0.12	0.15	28.8	65.0	1.85	42.0	1.30
% Remain	30	100	57	94	96		56	95

LEACH TEST: D1-24

PRODUCTS:

SUPERNATENT LIQUID: 15.8 kg

SETTLED SOLIDS: 3.42 kg
SOLIDS: 1.80 kg: 52%
LIQUID: 1.62 kg

TOTAL LIQUID: 17.4 kg sg: 1.36
VOLUME: 12.79 l

LEACH TEST: D1-24 DATE: 02/20/85

SOLUTION: 17.4 kg from Test: D3-17
NEW SOLUTION:
TOTAL SOLUTION: 17.4 kg sg: 1.31
VOLUME: 13.27 l

NEW SOLUTION:
H_2O:
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
$BaCl_2$: 0.30 kg (22.6 g/l)

SOLIDS:
TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 100-107°C

NOTES: Solids didn't settle well - remain relatively suspended.
299.4 g $BaCl_2$ added at start of leach.

MASS BALANCE LEACH TEST: D1-24 (BaCl, added)

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			974	974		944	944	30	3
Fe	421		712	1,133	377	739	1,116	17	2
Zn	695		338	1,033	291	681	972	61	6
Pb	214		193	407	5	398	403	4	1
Cu	19.5		8.3	27.8	11.0	12.8	23.8	4.0	14
Cl			3,956	3,956		3,665	3,665	291	7
S	872			875	783		800	75	9
SO_4^{2-}			8			51			
Au*	1.67			1.67	1.97		1.97	(.30)	
Ag*	532		155	687	220	469	689	(2)	
H_2O**			11.2	11.2		11.0	11.0	0.2	2
TOTAL**	2.4		17.4	19.8	1.8	17.5	19.3	0.5	3

* mg

** kg

SOLUTION ASSAYS TEST: D1-24

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	25.6	14.5	6.25	55.5	2.22	299	73.5	23.6	0.63	11.7
0.75	53.1	31.0	1.00	57.5	54.5	285	73.5	13.5	3.98	36.5

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.0								
0.75	16.2	0.26	0.61	20.9	43.5	16.44	122	140
% Remain.	42	2.3	56	90	90		41	118

LEACH TEST: D2-24

PRODUCTS:

SUPERNATENT LIQUID: 18.4 kg

SETTLED SOLIDS: 3.00 kg:
SOLIDS: 1.48 kg 49.03%
LIQUID: 1.52 kg

TOTAL LIQUID: 19.9 kg sg: 1.30
VOLUME: 15.31 l

LEACH TEST: D2-24 DATE: 02/21/85

SOLUTION: 3.99 kg from Test: D2-56
NEW SOLUTION: 15.6 kg
TOTAL SOLUTION: 19.6 kg sg: 1.26
VOLUME: 15.56 l

NEW SOLUTION:

H_2O: 9.26 kg
$FeCl_3 \cdot 6H_2O$: 2.87 kg
NaCl: 2.08 kg
$PbCl_2$: 0.19 kg
$ZnCl_2$: 0.10 kg
Conc HCl: 0.158 l
: 0.186 kg

SOLIDS:

TOTAL CONCENTRATE:
RESIDUE: 3.22 kg
SOLIDS: 1.92 kg: 49.03%
LIQUID: 1.30 kg sg: 1.27
VOLUME: 1.024 l

CONDITIONS:

TEST DURATION: 1.5 hr
TEMPERATURE: 107°C

NOTE: ½ normal HCl in lixiviant.

MASS BALANCE LEACH TEST: D2-24

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		83	1,090	1,173		1,138	1,138	35	3
Fe	355	65	750	1,170	339	834	1,173	(3)	
Zn	274	60	101	435	49	387	444	(9)	
Pb	5	35	177	217	3	213	220	(3)	
Cu	10.4	1.1	1.2	12.7	2.5	8.5	11.0	1.7	13
Cl		320	3,246	3,566		3,463	3,463	103	3
S	738			746	766		781	(35)	
SO_4^{2-}		4	23			44			
Au*	1.86	-	-	1.86	1.46	-	1.46	0.40	22
Ag*	207	41	27	275	99	148	247	28	10
H_2O**		1.0	13.7	14.7		13.8	13.8	0.9	6
TOTAL**	1.7	1.5	19.0	22.2	1.5	19.9	21.4	0.8	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-24

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	6.65	11.7	0.08	49.5	10.7	214	72.0	6.15	1.52	1.8
1.5	25.3	13.9	0.55	54.2	45.3	226	74.0	9.84	2.88	9.6

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
1.5	3.35	0.18	0.17	23.0	52.1	19.7	67.2	0.99
% Remain.	17.8	60.0	24.0	95.5	104		47.8	78.5

LEACH TEST: D2-57

PRODUCTS:

SUPERNATENT LIQUID: 4.22 kg

SETTLED SOLIDS: 1.95 kg

SOLIDS: 1.34 kg: 68.8%

LIQUID: 0.61

TOTAL LIQUID: 4.83 kg sg: 1.29

VOLUME: 3.744 l

LEACH TEST: D2-57 DATE: 02/12/85

SOLUTION: 1.93 kg

NEW SOLUTION: 4.23 kg

TOTAL SOLUTION: 6.16 kg sg: 1.24

VOLUME: 4.968 l

NEW SOLUTION:

H_2O: 2.34 kg

$FeCl_3 \cdot 6H_2O$: 0.73 kg

NaCl: 0.53 kg

$PbCl_2$: 0.05 kg

$ZnCl_2$: 0.03 kg

Conc HCl: 0.109 l

: 0.13 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.87 kg from Test: D2-24

SOLIDS: 0.94 Kg

LIQUID: 1.93 Kg

VOLUME: 1.496 L

CONDITIONS:

TEST DURATION: 5.0 hr

TEMPERATURE: 105°C

MASS BALANCE LEACH TEST: D2-57

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		111.0	238	349		228	228	121	35
Fe	339	78.9	158	576	307	177.3	484	92	16
Zn	49.3	37.8	12.6	99.7	15.8	60.5	76.3	23	23
Pb	2.6	20.8	35.8	29.2	32.8	40.0	72.8	(14)	
Cu	2.5	0.82	0.11	3.43	16.3	1.25	17.6	(14)	
Cl		338	689	1,027		707	707	320	31
S	766			766	711		711	55	7
SO_4^{2-}									
Au*	1.46		1.46	1.47		1.47	(0.1)		
Ag*	98.8	14.4	0.01	113	48.9	43.5	92.4	21	18
H_2O**		1.3	3.1	3.4		3.6	3.3	0.1	3
TOTAL**	1.5	1.9	4.2	7.6	1.3	4.8	6.1	1.5	20

* mg

** kg

SOLUTION ASSAYS TEST: D2-57

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	3.9	10.9	0.04	48.2	< 0.01	210	65.5	12.8	0.46	< 0.08
5.0	18.5	12.2	0.38	54.0	47.4	215.4	69.5	20.9	5.05	13.5

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final	1.18	0.25	0.12	22.9	53.1	20.00	36.5	1.10
% Remain.	32	100	100	91	93		49	101

LEACH TEST: D1-25

PRODUCTS:

SUPERNATENT LIQUID: 16.1 kg

SETTLED SOLIDS: 1.97 kg
SOLIDS: 1.08 kg: 55%
LIQUID: 0.89 kg

TOTAL LIQUID: 12.0 kg sg: 1.36
VOLUME: 12.52 l

LEACH TEST: D1-25 DATE: 02/22/85

SOLUTION: 17.5 kg from Test: D3-18
NEW SOLUTION: 0.70 kg
TOTAL SOLUTION: 18.3 kg sg: 1.32
VOLUME: 13.86 l

NEW SOLUTION:
H_2O: 0.700 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 100-105°C

NOTES: Addition of concentrate at 0.5 hour lead to boilover losing an estimated 10% of solids and leach solution.

MASS BALANCE LEACH TEST: D1-25 * 10% losses due to boilover on concentrate addition

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na			1,064	1,064		942	942	122	12
Fe	421		740	1,161	263	731	994	167	14
Zn	695		359	1,054	203	633	836	218	21
Pb	214		192	406	2	344	346	60	15
Cu	19.5		8.3	27.8	7.4	14.5	21.9	5.9	21
Cl			3,538	3,538		3,289	3,289	249	7
S	872			885	559		608	277	31
SO_4^{2-}			39			147			
Au*	1.67			1.67	1.08		1.08	.49	29
Ag*	532		176	708	164	444	608	100	14
H_2O**			12.3	12.3		10.8	10.8	1.5	12
TOTAL**	2.4		18.2	20.6	1.1	16.9	18.0	2.6	13

* mg

** kg

SOLUTION ASSAYS TEST: D1-25

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	26.7	13.8	0.59	52.9	0	253	76	13.3	2.82	12
0.75	50.8	27.6	1.16	58.6	52.9	264	75.5	5.84	11.8	30.6

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.75	18.8	0.15	0.69	24.2	51.6	1.68	152	0.99
% Remain.	29	0.9	38	62	64		31	65

LEACH TEST: D2-25

PRODUCTS:

SUPERNATENT LIQUID: 18.07 kg

SETTLED SOLIDS: 2.10 kg: 38.72%
SOLIDS: 0.81 kg
LIQUID: 1.29 kg

TOTAL LIQUID: 19.36 kg sg: 1.28
VOLUME: 15.13 l

LEACH TEST: D2-25 DATE: February 25, 1985

SOLUTION: 4.2 kg from Test: D2-57
NEW SOLUTION: 14.8 kg
TOTAL SOLUTION: 19.0 kg sg: 1.26
VOLUME: 15.1 l

NEW SOLUTION:
H_2O: 9.42 Kg
$FeCl_3\cdot6H_2O$: 2.82 kg
NaCl: 2.35 kg
$PbCl_2$: 0.19 kg
$ZnCl_2$: 0.10 kg
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 1.97 kg from Test: D1-25
SOLIDS: 1.08 kg 55.03%
LIQUID: 0.89 kg sg: 1.36
VOLUME: 0.65 l

CONDITIONS:
TEST DURATION: 1.5 hr
TEMPERATURE: 106°C

NOTE: No HCl in lixiviant.

MASS BALANCE LEACH TEST: D2-25

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		49	1,159	1,208		1,163	1,163	45	4
Fe	263	38	755	1,056	237	784	1,021	35	3
Zn	203	33	107	343	21	316	342	1	
Pb	2	18	175	195	1	219	226	(31)	
Cu	7.4	0.8	1.7	9.9	1.5	7.3	8.8	1.1	11
Cl		172	3,288	3,460		3,371	3,371	89	3
S	559			569	523		538	31	5
SO_4^{2-}		8	21			46			
Au*	1.08			1.08	1.06		1.06	0.02	2
Ag*	164	23	21	208	56	138	194	14	7
H_2O**		0.6	13.3	13.9		13.4	13.4	0.5	4
TOTAL**	1.1	0.9	19.1	21.1	0.8	19.4	20.2	0.9	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-25

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	7.1	11.6	0.12	49.9	13.1	217	77	3.5	1.41	2.80
1.5	20.9	14.5	0.48	51.9	41.6	223	77	7.6	3.03	9.12

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
Final	2.55	0.14	0.18	29.1	64.2	1.56	68.6	1.30
% Remain.	10	50	20	90	94		34	98

LEACH TEST: D2-58 DATE: 02/25/85

SOLUTION:

NEW SOLUTION: 3.81 kg

TOTAL SOLUTION: 3.81 kg sg: 1.24

VOLUME: 3.07 l

NEW SOLUTION:

H_2O: 2.34 kg

$FeCl_3 \cdot 6H_2O$: 0.73 kg

NaCl: 0.53 kg

$PbCl_2$: 0.05 kg

$ZnCl_2$: 0.03 kg

Conc HCl: 0.11 l

: 0.13 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.10 kg from Test: D2-25

SOLIDS: 0.81 kg: 38.72%

LIQUID: 1.29 kg sg: 1.30

VOLUME: 0.992 l

CONDITIONS:

TEST DURATION: 5.0 hr

TEMPERATURE: 107°C

LEACH TEST: D2-58

PRODUCTS:

SUPERNATENT LIQUID: 4.03 kg

SETTLED SOLIDS: 1.43 kg

SOLIDS: 0.83 kg: 57.7%

LIQUID: 0.60 kg

TOTAL LIQUID: 4.63 kg sg: 1.23

VOLUME: 3.764 l

MASS BALANCE LEACH TEST: D2-58

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		77	205	283		258	258	25	9
Fe	237	52	152	441	238	192	430	11	2
Zn	21	21	12	54	6	49	55	(1)	
Pb	1	15	34	50	2	44	46	4	8
Cu	1.5	0.5		2.0	0.9	1.2	2.1	(0.1)	
Cl		224	663	887		799	799	88	10
S	523			524	550		557	(33)	
SO_4^{2-}		3				21			
Au*	1.06			1.06	1.24		1.24	(.18)	
Ag*	56	9		65	28	35	63	2	3
H_2O**		0.9	2.7	3.6		3.3	3.3	0.3	8
TOTAL**	0.8	1.3	3.8	5.9	0.8	4.6	5.4	0.5	8

* mg

** kg

SOLUTION ASSAYS TEST: D2-58

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	4.0	11.0	<0.1	49.7	0.2069	217	67	13.0	0.54	<0.0
5.0	13.5	12.1	0.32	52.9	46.8	220	71	20.4	5.86	9.6

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
1.5	0.74	0.23	0.11	28.9	66.7	1.48	34.6	1.51
% Remain. 29	200	60	100	105			50	117

LEACH TEST: D1-26

PRODUCTS:

SUPERNATENT LIQUID: 16.8 kg

SETTLED SOLIDS: 2.53 kg
SOLIDS: 1.45 kg: 57%
LIQUID: 1.08 kg

TOTAL LIQUID: 17.9 kg sg: 1.35
VOLUME: 13.26 l

LEACH TEST: D1-26 DATE: 02/26/85

SOLUTION: 17.4 kg from Test: D3-19
NEW SOLUTION: 0.49 kg
TOTAL SOLUTION: 17.9 kg sg: 1.35 g/cc
VOLUME: 13.16 l

NEW SOLUTION:
H_2O: 0.49 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.44 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 100-106°C

NOTES: Add 10% concentrate at 0.5 hr.

MASS BALANCE LEACH TEST: D1-26

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na			1,056	1,056		1,000	1,000	5.60	5
Fe	421		743	1,164	380	787	1,167	(3)	0
Zn	695		291	986	286	646	932	54	5
Pb	241		187	428	3	447	450	(22.0)	0
Cu	19.5		6.5	26.0	11.2	9.2	20.4	5.6	22
Cl			3,471	3,471		3,368	3,368	103	3
S	872			872	756		809	63	7
SO_4^{2-}			42.3	42.3		158			
Au*	1.67			1.67	1.59		1.59	.08	5
Ag*	532		133	665	210	423	633	32	5
H_2O**			11.99	12.0		11.5	11.5	0.5	4
TOTAL**	2.4		17.9	20.3	1.4	17.9	19.3	1.0	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-26

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	21.1	13.7	0.47	53.8	0	251	76.5	9.08	3.06	9.6
0.75	48.8	33.7	0.93	59.4	55.2	254	75.5	4.62	12.0	31.9

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.0								
0.75	19.8	0.21	0.78	25.7	52.2	1.31	145	1.10
% Remain.	41	1.2	57	90	87		39	95

LEACH TEST: D2-26

PRODUCTS:

SUPERNATENT LIQUID: 18.04 kg

SETTLED SOLIDS: 2.91 kg: 36.75%
SOLIDS: 1.07 kg
LIQUID: 1.84 kg

TOTAL LIQUID: 19.88 kg sg: 1.28
VOLUME: 15.53 l

LEACH TEST: D2-26 DATE: 02/26/85

SOLUTION: 4.0 kg from Test: D2-58
NEW SOLUTION: 15.0 kg
TOTAL SOLUTION: 19.0 kg sg: 1.26
VOLUME: 15.1 l

NEW SOLUTION:
H_2O: 9.24 kg
$FeCl_3\cdot6H_2O$: 2.86 kg
NaCl: 2.07 kg
$PbCl_2$: 0.19 kg
$ZnCl_2$: 0.10 kg
Conc HCl: 0.43 l
: 0.51 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.10 kg from Test: D1-26
SOLIDS: 1.20 Kg: 57.2%
LIQUID: 0.90 kg sg: 1.35
VOLUME: 0.67 l

CONDITIONS:
TEST DURATION: 1.5 hr
TEMPERATURE: 106°C

MASS BALANCE LEACH TEST: D2-26

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		50	1,001	1,051		1,076	1,076	(25)	
Fe	315	40	764	1,119	311	831	1,142	(23)	
Zn	237	32	90	359	37	370	415	(56)	
Pb	2	22	172	196	1	196	202	(6)	
Cu	9.3	0.5	0.9	10.7	1.9	9.9	11.8	(1.1)	
Cl		169	3,276	3,445		3,434	3,434	11	0
S	627			638	685		701	(63)	
SO_4^{2-}		8	26			47			
Au*	1.32			1.32	1.39		1.39	(.07)	
Ag*	174	21	23	218	71	169	240	(22)	0
H_2O**		0.6	13.7	14.3		13.9	13.9	0.4	3
TOTAL**	1.2	0.9	19.0	21.1	1.1	19.9	21.0	0.1	

* mg

** kg

SOLUTION ASSAYS TEST: D2-26

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	6.0	11.4	0.06	50.7	11.7	218	67	15.1	1.74	1.56
1.5	23.9	12.7	0.64	53.7	49.3	222	70	15.8	3.07	10.9

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
1.5	3.5	0.11	0.18	29.1	64.1	1.22	66.3	1.30
% Remain.	16	50	20	99	109		41	105

LEACH TEST: D2-59

PRODUCTS:

SUPERNATENT LIQUID: 4.69 kg

SETTLED SOLIDS: 1.82 kg: 59.34%
SOLIDS: 1.08 kg
LIQUID: 0.74 kg

TOTAL LIQUID: 5.43 kg sg: 1.274
VOLUME: 4.26 l

LEACH TEST: D2-59 DATE: 02/27/85

SOLUTION:
NEW SOLUTION: 3.81 kg
TOTAL SOLUTION: 3.81 kg sg: 1.24
VOLUME: 3.07 l

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3 \cdot 6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$: 0.05 kg
$ZnCl_2$: 0.03 kg
Conc HCl: 0.11 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.91 kg from Test: D2-26
SOLIDS: 1.07 kg: 36.75%
LIQUID: 1.84 kg sg: 1.284
VOLUME: 1.43 l

CONDITIONS:
TEST DURATION: 5.0 hr
TEMPERATURE: 106°C

MASS BALANCE LEACH TEST: D2-59

(g)	IN SOLIDS	IN SLURRY LIQUID	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% Δ/IN
Na		99	209	308		306	306	2	0
Fe	311	77	146	534	319	222	541	(7)	
Zn	37	34	12	83	8	76	84	(1)	
Pb	1	18	32	51	2	48	50	1	2
Cu	1.9	0.9		2.8	1.2	1.9	3.1	(0.3)	
Cl		317	645	962		937	937	25	3
S	685			687	715		723	(36)	
SO_4^{2-}		4	2			23			
Au*	1.39			1.39	1.48		1.48	(0.07)	
Ag*	71	16		87	33	58	91	(4)	
H_2O**		1.3	2.7	4.0		3.8	3.8	0.2	5
TOTAL**	1.1	1.8	3.8	6.7	1.1	5.4	6.5	0.2	3

* mg

** kg

SOLUTION ASSAYS TEST: D2-59

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	3.8	10.4		47.8	0	210	68	14.6	0.57	
5.0	17.8	11.2	0.45	52.1	49.2	220	72	25.0	5.41	13.7

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final 5.0	0.70	0.18	0.11	29.5	66.1	1.38	30.7	1.37
% Remain.	22	200	63	103	104		46	106

LEACH TEST: D1-27

PRODUCTS:

SUPERNATENT LIQUID: 17.19 kg

SETTLED SOLIDS: 2.56 kg
SOLIDS: 1.46 kg: 57%
LIQUID: 1.10 kg

TOTAL LIQUID: 18.3 kg .sg: 1.34
VOLUME: 13.66 l

LEACH TEST: D1-27 DATE: 02/28/85

SOLUTION: 16.5 kg from Test: D3-20
NEW SOLUTION: 1.22 kg
TOTAL SOLUTION: 17.74 kg sg: 1.31
VOLUME: 13.54 Kg

NEW SOLUTION:
H_2O: 1.22 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.41 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 100-107°C

NOTE: Concentrate washed ½ hour in pH 4 HCl Solution.

MASS BALANCE LEACH TEST: D1-27

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL inc. wash		
Na			964	964		958	958	6	1
Fe	417		724	1,141	370	784	1,154	(13)	0
Zn	689		331	1,020	282	586	888	132	13
Pb	212		171	383	4	373	384	(1)	
Cu	19.3		8.9	28.2	7.3	14.8	22.1	6.1	22
Cl			3,387	3,387		3,348	3,348	39	1
S	864			879	762		800	79	9
SO_4^{2-}			44			114			
Au*	1.66			1.66	1.61		1.61	.05	3
Ag*	527		135	662	220	454	674	(12)	
H_2O**		0.4	12.1	12.5		12.1	12.1	0.4	3
TOTAL**	2.4	0.4	17.7	20.5	1.5	18.3	19.8	0.7	3

* mg

** kg

SOLUTION ASSAYS TEST: D1-27

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	24.1	12.5	0.65	52.6	<1	246	70	19.1	3.23	9.8
0.75	42.8	27.3	1.09	57.3	49.8	245	69.5	14.1	8.35	33.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
0.75	19.3	0.25	0.50	25.3	52.0	1.15	150	1.10
% Remain.	41	1. 9	38	89	88		42	97

LEACH TEST: D2-27 DATE: 03/01/85

SOLUTION: 4.6 kg from Test: D2-59

NEW SOLUTION: 14.4 Kg

TOTAL SOLUTION: 19.0 kg sg: 1.26

VOLUME: 15.1 1

NEW SOLUTION:

H_2O: 8.90 kg

$FeCl_3 \cdot 6H_2O$: 2.76 kg

NaCl: 2.00 kg

$PbCl_2$: 0.18 kg

$ZnCl_2$: 0.10 kg

Conc HCl: 0.41 1

: 0.48 kg

SOLIDS:

TOTAL CONCENTRATE:

RESIDUE: 2.54 kg from Test: D1-27

SOLIDS: 1.45 kg: 57.08%

LIQUID: 1.09 kg sg: 1.33

VOLUME: 1.82 1

CONDITIONS:

TEST DURATION: 1.5 hr

TEMPERATURE: 106°C

LEACH TEST: D2-27

PRODUCTS:

SUPERNATENT LIQUID: 17.81 kg

SETTLED SOLIDS: 2.77 kg:

SOLIDS: 1.02 kg 36.87%

LIQUID: 1.75 kg

TOTAL LIQUID: 19.56 kg sg: 1.277

VOLUME: 15.32 1

MASS BALANCE LEACH TEST: D2-27

	IN				OUT				
(g)	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL	DIFF. IN-OUT (gain)	% △/IN
Na		61	1,044	1,105		1,080	1,080	25	2
Fe	366	50	820	1,236	289	773	1,062	174	14
Zn	279	37	107	423	41	410	460	(37)	
Pb	4	24	177	205	1	208	215	(10)	
Cu	7.2	0.9	1.5	9.6	1.6	10.6	12.2	(2.6)	
Cl		212	3,306	3,518		3,388	3,388	130	4
S	754			765	650		664	101	13
SO_4^{2-}		7	25			43			
Au*	1.59			1.59	1.22		1.22	0.37	23
Ag*	218	29	43	290	86	189	275	15	5
H_2O**		0.8	13.5	14.3		13.6	13.6	0.7	5
TOTAL**	1.4	1.1	19.0	21.5	1.0	19.6	20.6	0.9	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-27

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	7.1	11.7	0.10	54.2	11.7	218	69	15.7	1.66	2.8
1.5	26.8	13.6	0.70	50.4	41.9	221	71	16.9	2.79	12.3

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final 1.5	4.00	0.10	0.11	28.3	63.8	1.38	84.3	1.20
% Remain.	15	25	22	79	86		39	77

LEACH TEST: D2-60

PRODUCTS:

SUPERNATENT LIQUID: 4.52 kg

SETTLED SOLIDS: 1.76 kg: 63.83%
SOLIDS: 1.12 kg
LIQUID: 0.64 kg

TOTAL LIQUID: 5.16 kg sg: 1.274
VOLUME: 4.05 l

LEACH TEST: D2-60 DATE: 03/04/85

SOLUTION:
NEW SOLUTION: 3.81 kg
TOTAL SOLUTION: 3.81 kg sg: 1.25
VOLUME: 3.05 l

NEW SOLUTION:
H_2O: 2.34 kg
$FeCl_3\cdot6H_2O$: 0.73 kg
NaCl: 0.53 kg
$PbCl_2$: 0.05 kg
$ZnCl_2$: 0.03 kg
Conc HCl: 0.11 l
: 0.13 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.75 kg from Test: D2-27
SOLIDS: 1.01 kg: 36.87
LIQUID: 1.74 kg sg: 1.277
VOLUME: 1.36 l

CONDITIONS:
TEST DURATION: 5.0 hr
TEMPERATURE: 105.5°C

MASS BALANCE LEACH TEST: D2-60

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		96	204	300		275	275	25	8
Fe	288	69	149	506	326	221	547	(41)	
Zn	41	36	12	89	6	77	83	6	7
Pb	1	18	35	54	1	51	52	2	4
Cu	1.6	0.9		2.5	1.2	2.1	3.3	(0.8)	
Cl		301	662	963		899	899	64	7
S	647			648	722		729	(81)	
SO_4^{2-}		4				20			
Au*	1.21			1.21	1.46		1.46	(0.25)	
Ag*	86	17		103	51	72	123	(20)	
H_2O**		1.2	2.7	3.9		3.6	3.6	0.3	8
TOTAL**	1.0	1.7	3.8	6.5	1.1	5.2	6.3	0.2	3

* mg

** kg

SOLUTION ASSAYS TEST: D2-60

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	3.8	11.5		48.9	0	217	67	13.8		
5.0	19.0	12.5	0.51	54.6	45.6	222	68	22.0	4.92	17.9

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	Insol (%)	Ag (ppm)	Au (ppm)
5.0	0.56	0.10	0.11	29.1	64.5	1.46	45.9	1.30
% Remain.	15	100	75	113	112		59	121

LEACH TEST: D1-28

PRODUCTS:

SUPERNATENT LIQUID: 16.4 kg

SETTLED SOLIDS: 2.67 kg
SOLIDS: 1.40 kg: 52%
LIQUID: 1.27 kg

TOTAL LIQUID: 17.7 kg sg: 1.35
VOLUME: 13.11 l

LEACH TEST: D1-28 DATE: 03/15/85

SOLUTION: 16.60 kg from Test: D3-21
NEW SOLUTION: 0.94 Kg
TOTAL SOLUTION: 17.5 kg sg: 1.295
VOLUME: 13.5 l

NEW SOLUTION:
H_2O: 0.94 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.38 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 100-106°C

NOTE: Concentrate washed 1 hour in pH 4 HCl Solution.

MASS BALANCE LEACH TEST: D1-28

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na			952	952		913	913	39	4
Fe	411		741	1,152	353	778	1,131	21	2
Zn	679		335	1,014	266	678	944	70	7
Pb	235		184	419	3	390	393	26	6
Cu	19.1		9.9	29.0	9.0	18.6	27.6	1.4	5
Cl			3,510	3,510		3,377	3,377	133	4
S	852			865	719		763	102	12
SO_4^{2-}			40			132			
Au*	1.63			1.63	1.39		1.39	0.24	15
Ag*	520		181	701	194	498	692	9	1
H_2O**			11.8	11.8		11.3	11.3	0.5	4
TOTAL**	2.4		17.5	19.9	1.4	17.6	19.0	0.9	5

* mg

** kg

SOLUTION ASSAYS TEST: D1-28

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	24.8	13.6	0.73	54.9	1.56	260	70.5	19.5	2.93	13.4
0.75	52.0	29.9	1.43	59.7	51.6	259	70	15.2	10.1	38.2

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
0.75	19.0	0.19	0.64	25.2	51.4	1.73	139	0.99
% Remain.	39	1.3	47	86	84		37	85

LEACH TEST: D2-28 DATE: 03/06/85

SOLUTION: 4.40 kg from Test: D2-60
NEW SOLUTION: 14.6 kg
TOTAL SOLUTION: 19.0 kg sg: 1.256
VOLUME: 15.1 l

NEW SOLUTION:
H_2O: 9.00 kg
$FeCl_3 \cdot 6H_2O$: 2.79 kg
NaCl: 2.02 kg
$PbCl_2$: 0.19 kg
$ZnCl_2$: 0.10 kg
Conc HCl: 0.42 l
: 0.50 kg

SOLIDS:
TOTAL CONCENTRATE:
RESIDUE: 2.66 kg from Test: D1-28
SOLIDS: 1.39 kg: 52.33%
LIQUID: 1.27 kg sg: 1.352
VOLUME: 0.94 l

CONDITIONS:
TEST DURATION: 1.5 hr
TEMPERATURE: 106°C

LEACH TEST: D2-28

PRODUCTS:

SUPERNATENT LIQUID: 17.96 kg

SETTLED SOLIDS: 2.86 kg: 37.48%
SOLIDS: 1.07 kg
LIQUID: 1.79 kg

TOTAL LIQUID: 19.75 kg sg: 1.283
VOLUME: 15.39 l

MASS BALANCE LEACH TEST: D2-28

(g)	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na		66	1,072	1,139		1,085	1,085	54	5
Fe	353	56	769	1,178	306	816	1,122	56	5
Zn	266	49	122	437	33	392	425	12	3
Pb	3	28	186	217	1	211	212	5	2
Cu	9.0	1.3	1.8	12.1	1.8	9.8	11.6	0.5	4
Cl		243	3,367	3,610		3,432	3,432	178	5
S	719			729	682		695	34	5
SO_4^{2-}		10	20			40			
Au*	1.39			1.39	1.28		1.28	0.11	8
Ag*	194	36	56	286	30	195	225	71	25
H_2O**		0.8	13.5	14.3		13.8	13.8	0.5	3
TOTAL**	1.4	1.3	19.0	21.7	1.1	19.8	20.9	0.8	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-28

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	8.1	12.3	0.12	50.9	12.4	223	71	14.9	1.32	3.7
1.5	25.5	13.7	0.64	53.0	47.6	223	70.5	16.2	2.63	12.7

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final								
1.5	3.05	0.12	0.17	28.6	63.7	1.73	28.3	1.20
% Remain.	12	33	20	87	95		15	92

LEACH TEST: D2-61

PRODUCTS:

SUPERNATENT LIQUID:	4.35	kg		
Settled Solids:		kg		
Solids:	1.09	kg		
Liquid:		kg		
Total Liquid:	4.35	kg	sg:	1.28
Volume:	3.40	l		

LEACH TEST: D2-61 **DATE: Mar. 6/85**

SOLUTION:			
NEW SOLUTION:	3.81	kg	
TOTAL SOLUTION:	3.81	kg	sg: 1.25
VOLUME:	3.05	l	

NEW SOLUTION:

H_2O:	2.34	kg	
$FeCl_3$ GH_2O:	0.73	kg	
NaCl:	0.53	kg	
$PbCl_2$:	0.05	kg	
$ZnCl_2$:	0.03	kg	
Conc HCl:	0.11	l	
:	0.13	kg	

SOLIDS:

Total Concentrate:

Residue:	2.86	kg	From Test: D2-28
Solids:	1.07	kg	37.48%
Liquid:	1.79	kg	sg: 1.283
Volume:	1.40	l	

CONDITIONS:

Test Duration:	5.0	hr.
Temperature:	107	°C

NOTES:

MASS BALANCE LEACH TEST: D2-61

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	98	210	306	-	235	235	73	24
Fe	306	74	153	533	318	181	499	34	6
Zn	33	36	13	82	4	64	68	14	17
Pb	1	19	38	58	1	45	46	12	21
Cu	1.8	0.9	-	2.7	0.7	1.6	2.3	0.4	15
Cl	-	311	647	958	-	728	728	230	24
S	682	-	-	684	748	-	754	(70)	-
SO_4^{2-}	-	4	1	-	-	17	-	-	-
Au*	1.28	-	-	1.28	1.42	-	1.42	(0.14)	-
Ag*	30	18	0	48	38	60	98	(50)	-
H_2O**	-	1.3	2.7	4.0	-	3.1	3.1	0.9	23
OTAL**	1.1	1.8	3.8	6.7	1.1	4.3	5.4	1.3	19

* mg

** kg

SOLUTION ASSAYS TEST: D2-61

Time Hr.	Zn g/1	Pb g/1	Cu g/1	Fe g/1	Fe^{2+} g/1	Cl g/1	Na g/1	H+ g/1	SO_4^{2-} g/1	Ag ppm
0	4.3	12.4	0	50.2	0	212	69	14.0	0.36	0
5.0	18.8	13.3	0.47	53.2	49.8	214	69	16.0	5.05	17.5

SOLIDS ASSAYS:

Time Hr.	Zn %	Pb %	Cu %	Fe %	S %	insol %	Ag ppm	Au ppm
5.0	0.37	0.08	.066	29.1	68.5	1.72	34.7	1.30
% Remain	12	100	39	104	110	-	126	111

only in
3rd stage
balance

LEACH TEST: D1-29

PRODUCTS:

SUPERNATENT LIQUID: 16.4 kg

SETTLED SOLIDS: 2.49 kg
SOLIDS: 1.32 kg: 53%
LIQUID: 1.17 kg

TOTAL LIQUID: 17.6 kg sg: 1.36
VOLUME: 12.94 l

LEACH TEST: D1-29 DATE: 03/08/85

SOLUTION: 17.6 kg from Test: D3-22 & D3-23
NEW SOLUTION: 0.13 kg
TOTAL SOLUTION: 17.8 kg sg: 1.30
VOLUME: 13.69 l

NEW SOLUTION:
H_2O: 0.13 kg
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.30 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 106°C

NOTES:
10% concentrate added at 0.50 hr.

MASS BALANCE LEACH TEST: D1-29

(g)	IN			OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	975	975	-	932	932	43	4
Fe	397	704	1101	321	752	1073	28	3
Zn	656	337	993	235	696	931	62	6
Pb	202	189	391	1	383	384	7	2
Cu	18.4	7.5	25.9	9.1	14.0	23.1	2.8	11
Cl	-	3559	3559	-	3533	3533	26	1
S	823	-	836	713	-	765	71	8
SO_4^{2-}	-	38	-	-	155	-	-	-
Au*	1.57	-	1.57	1.31	-	1.31	0.26	17
Ag*	502	158	660	191	445	636	24	4
H_2O**	-	13.2	13.2	-	11.4	11.4	1.8	14
TAL**	2.3	17.8	20.1	1.3	17.6	18.9	1.2	6

* mg
** kg

SOLUTION ASSAYS TEST: D1-29

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	24.6	13.8	0.55	51.4	0	260	71.2	23.5	2.86	12.2
0.75	53.8	29.6	1.08	58.1	51.8	273	72	7.96	12.2	34.4

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final	17.8	0.11	0.68	24.3	53.5	1.53	144.6	0.99
% Remain.	36	0.4	49	81	87		38	83

LEACH TEST: D2-29

PRODUCTS:

SUPERNATENT LIQUID:	18.0	kg	
Settled Solids:	2.94	kg	@ 32.2%
Solids:	.95	kg	
Liquid:	1.99	kg	
Total Liquid:	20.0	kg	sg: 1.29
Volume:	15.5	l	

LEACH TEST: D2-29 DATE: Mar 11/85

SOLUTION:			
NEW SOLUTION:	19.1	kg	
TOTAL SOLUTION:	19.1	kg	sg: 1.25
VOLUME:	15.3	l	

NEW SOLUTION:

H_2O:	12.12	kg
$FeCl_3$ GH_2O:	3.63	kg
NaCl:	3.02	kg
$PbCl_2$:	0.24	kg
Conc HCl:	-	l
$ZnCl_2$:	0.13	kg

SOLIDS:

Total Concentrate:

Residue:	2.45	kg	From Test: D1-29
Solids:	1.31	kg	@ 53.58%
Liquid:	1.14	kg	sg: 1.36
Volume:	0.84	l	

CONDITIONS:

Test Duration:	1.5	hr.
Temperature:	107	^oC

NOTES: No HCl in lixiviant.

MASS BALANCE LEACH TEST: D2-29

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	61	1181	1242	-	1234	1234	8	1
Fe	321	49	765	1135	263	812	1075	60	5
Zn	235	45	61	341	31	282	313	28	8
Pb	1	25	170	196	1	198	199	(3)	0
Cu	9.1	0.9	-	10.0	2.0	5.5	7.5	2.5	25
Cl	-	229	3335	3564	-	3457	3475	89	2
S	713	-	-	719	615	-	633	86	12
SO_4^{2-}	-	10	8	-	-	53	-	-	-
Au*	1.31	-	-	1.31	1.23	-	1.23	0.08	6
Ag*	191	29	-	220	60	147	207	13	6
H_2O**	-	0.7	13.6	14.3	-	14.0	14.0	0.3	2
OTAL**	1.3	1.1	19.1	21.5	0.9	20.0	20.9	0.6	3

* mg

** kg

SOLUTION ASSAYS TEST: D2-29

Time Hr.	Zn g/l	Pb g/l	Cu g/l	Fe g/l	Fe^{2+} g/l	Cl g/l	Na g/l	H + g/l	SO_4^{2-} g/l	Ag ppm
0	4.0	11.1	.035	50.0	0	218	77.2	3.3	0.52	0
1.5	18.2	12.8	.353	52.4	41.0	223	79.6	9.8	3.39	9.5

SOLIDS ASSAYS:

Time Hr.	Zn %	Pb %	Cu %	Fe %	S %	insol %	Ag ppm	Au ppm
Final	3.3	0.09	0.21	27.8	65.0	1.66	63.2	1.30
% Remain	13	100	22	82	86	-	31	94

LEACH TEST: D1-30

PRODUCTS:

SUPERNATENT LIQUID: 17.07 kg

Settled Solids: 2.39 kg
Solids: 1.32 kg 55.3%
Liquid: 1.07 kg

Total Liquid: 18.14 kg sg: 1.35 kg/1
Volume: 13.42 1

LEACH TEST: D1-30 DATE: 03/11/85

SOLUTION: 17.4 kg from Test: D3-24
NEW SOLUTION:
TOTAL SOLUTION: 17.4 kg sg: 1.30
VOLUME: 13.4 1

NEW SOLUTION:
H_2O:
$FeCl_3 \cdot 6H_2O$:
NaCl:
$PbCl_2$:
$ZnCl_2$:
Conc HCl:
:

SOLIDS:
TOTAL CONCENTRATE: 2.30 kg
RESIDUE:
SOLIDS:
LIQUID:
VOLUME:

CONDITIONS:
TEST DURATION: 0.75 hr
TEMPERATURE: 105-106°C

MASS BALANCE LEACH TEST: D1-30

(g)	IN			OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	1072	1072	-	1107	1107	(35)	0
Fe	397	696	1093	322	786	1108	(15)	0
Zn	656	248	904	234	601	835	69	8
Pb	202	178	380	2	384	386	(6)	0
Cu	18.4	4.8	23.2	10.2	10.6	20.8	2.4	10
Cl	-	3874	3874	-	3461	3461	413	11
S	823	-	839	709	-	768	71	8
SO_4^{2-}	-	49	-	-	176	-	-	-
Au*	1.57	-	1.57	1.45	-	1.45	0.12	8
Ag*	502	138	640	197	421	618	22	3
H_2O**	-	11.2	11.2	-	11.6	11.6	(0.4)	0
TOTAL**	2.3	17.4	19.7	1.3	18.1	19.4	0.3	2

* mg

** kg

SOLUTION ASSAYS TEST: D1-30

TIME (hr)	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Cl (g/l)	Na (g/l)	H^+ (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0.0	18.5	13.3	0.36	51.9	0	289	80		3.64	10.32
0.75	44.8	28.6	0.79	58.6	54.5	257.9	82.5	7.47	13.1	31.4

SOLIDS ASSAYS:

TIME (hr)	Zn (%)	Pb (%)	Cu (%)	Fe (%)	S (%)	insol (%)	Ag (ppm)	Au (ppm)
Final	17.7	0.13	0.77	24.4	53.7	1.74	149	1.10
% Remain.	36	1.0	55	81	86		39	92

LEACH TEST: D2-30

PRODUCTS:

SUPERNATENT LIQUID:	17.76	kg	
Settled Solids:	2.86	kg	
Solids:	0.98	kg	@ 34.18%
Liquid:	1.88	kg	
Total Liquid:	19.64	kg	sg: 1.29
Volume:	15.27	l	

LEACH TEST: D2-30 **DATE:** Mar. 25/85

SOLUTION:			
NEW SOLUTION:	19.1	kg	
TOTAL SOLUTION:	19.1	kg	sg: 1.26
VOLUME:	15.2	l	
NEW SOLUTION: H_2O:	12.12	kg	
$FeCl_3$ GH_2O:	3.63	kg	
NaCl:	3.02	kg	
$PbCl_2$:	0.24	kg	
Conc HCl:	-	l	
$ZnCl_2$:	0.13	kg	
SOLIDS:			
Total Concentrate:		kg	
Residue:	2.35	kg	From Test: D1-30
Solids:	1.30	kg	55.34%
Liquid:	1.05	kg	sg: 1.35
Volume:	0.78	l	
CONDITIONS:			
Test Duration:	1.5	hr.	
Temperature:	105-7 °C		

NOTES: No HCl in Lixiviant.

MASS BALANCE LEACH TEST: D2-30

(g)	IN				OUT			DIFF. IN-OUT (gain)	% Δ/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	64	1224	1288	-	1206	1206	82	6
Fe	322	46	727	1094	266	744	1010	84	8
Zn	234	35	58	327	45	282	327	0	0
Pb	2	22	175	199	1	197	198	1	1
Cu	10.2	0.6	0	10.8	2.6	6.4	9.0	1.8	17
Cl	-	201	3405	3606	-	3451	3451	155	4
S	709	-	-	714	620	638	638	76	11
SO_4^{2-}	-	10	5	-	-	-	-	-	-
Au*	1.45	-	-	1.45	1.38	1.38	1.38	0.07	5
Ag*	197	24	0	221	67	217	217	4	2
H_2O**	-	0.7	13.5	14.2	-	13.7	13.7	0.5	4
TOTAL**	1.3	1.1	19.1	21.5	1.0	19.6	20.6	0.9	4

* mg

** kg

SOLUTION ASSAYS TEST: D2-30

Time Hr.	Zn g/l	Pb g/l	Cu g/l	Fe g/l	Fe^{3+} g/l	Cl g/l	Na g/l	H+ g/l	SO_4^{2-} g/l	Ag ppm
0	3.8	11.5	0.03	47.8		224	80.5	0	0.31	0.70
.08	11.1	12.6	0.21	47.9	36.6	224	-	0	1.77	3.60
.17	13.1	12.5	0.24	48.0	29.7	223	-	0	2.31	4.96
.50	15.0	12.7	0.30	48.8	23.6	225	-	2.4	2.59	6.68
1.50	18.5	12.9	0.42	48.7	13.3	226	79	4.3	3.45	9.80

SOLIDS ASSAYS:

Time Hr.	Zn %	Pb %	Cu %	Fe %	S %	insol %	Ag ppm	Au ppm
1.50	4.6	0.13	0.27	27.2	63.5	1.76	68.2	1.41
% Remain	19	50	25	83	87	-	34	95

LEACH TEST: D2-62

PRODUCTS:

SUPERNATENT LIQUID:	4.25	kg	
Settled Solids:	1.65	kg	60.35%
Solids:	1.00	kg	
Liquid:	0.65	kg	
Total Liquid:	4.90	kg	sg: 1.28
Volume:	3.83	l	

LEACH TEST: D2-62

DATE: Mar. 25/85

SOLUTION:			
NEW SOLUTION:	3.83	kg	
TOTAL SOLUTION:	3.83	kg	sg: 1.26
VOLUME:	3.04	l	

NEW SOLUTION:

H_2O:	2.42	kg
$FeCl_3$ GH_2O:	0.73	kg
NaCl:	0.61	kg
$PbCl_2$:	0.05	kg
Conc HCl:	-	l
$ZnCl_2$:	0.03	kg

SOLIDS:

Total Concentrate:		kg	
Residue:	2.86	kg	From Test: D2-30
Solids:	0.98	kg	34.18%
Liquid:	1.88	kg	sg: 1.29
Volume:	1.45	l	

CONDITIONS:

Test Duration: 5.0 Hr.

Temperature: 106°C

NOTES: No HCl in lixiviant.

MASS BALANCE LEACH TEST: D2-62

(g)	IN				OUT			DIFF. IN-OUT (gain)	% △/IN
	SOLIDS	SLURRY LIQUID	SOLU-TION	TOTAL	SOLIDS	SOLU-TION	TOTAL		
Na	-	115	240	355	-	314	314	41	12
Fe	266	71	144	481	271	193	464	17	4
Zn	45	27	12	84	16	67	83	1	1
Pb	1	19	36	56	1	44	45	11	20
Cu	2.6	0.6	0	3.2	1.6	1.7	3.3	(0.1)	0
Cl	-	328	672	1000	-	850	850	150	15
S	620	-	-	627	636	-	643	(21)	0
SO_4^{2-}	-	5	1	-	-	21	-	-	-
Au*	1.38	-	-	1.38	1.78	-	1.78	(0.40)	0
Ag*	67	14	-	81	39	47	86	(5)	0
H_2O**	-	1.3	2.7	4.0	-	3.4	3.4	0.6	15
TAL**	1.0	1.9	3.8	6.7	1.0	4.9	5.9	0.8	12

* mg

* kg

SOLUTION ASSAYS TEST: D2-62

Time Hr.	Zn g/l	Pb g/l	Cu g/l	Fe g/l	Fe^{3+} g/l	Cl g/l	Na g/l	H+ g/l	SO_4^{2-} g/l	Ag ppm
0	4.0	11.8	0.03	47.5	-	221	79	0.8	0.31	0.78
1.0	14.0	12.3	0.33	52.5	15.6	234	-	10.8	4.72	9.44
2.0	15.2	11.8	0.38	50.1	7.9	223	-	11.7	5.03	10.88
3.0	16.4	11.8	0.43	51.1	4.4	-	-	12.1	5.37	11.68
4.0	16.9	11.7	0.43	50.5	1.6	-	-	11.9	5.44	11.72
5.0	17.5	11.6	0.44	50.4	0.3	222	82	11.1	5.46	12.40

SOLIDS ASSAYS:

Time Hr.	Zn %	Pb %	Cu %	Fe %	S %	insol %	Ag ppm	Au ppm	
1.0	3.4	0.08	0.23	-	-	-	-	-	
2.0	2.4	0.08	0.23	-	-	-	-	-	
3.0	1.9	0.07	0.25	-	-	-	-	-	
4.0	1.6	0.07	0.20	-	-	-	-	-	
Final	1.6	0.07	0.16	27.1	63.7	1.59	38.8	1.78	
% Remain	36	100	62	102	103	-	58	129	?

LEACH TEST: D1-31

PRODUCTS:

SUPERNATENT LIQUID:	15.87	kg	
Settled Solids:	2.93	kg	@ 44.79%
Solids:	1.31	kg	
Liquid:	1.52	kg	
Total Liquid:	17.49	kg	sg: 1.35
Volume:	12.96	l	

LEACH TEST: D1-31 **DATE:** Mar. 26/85

SOLUTION:	17.7	kg	from Test : D3-25
NEW SOLUTION:		kg	
TOTAL SOLUTION:	17.7	kg	sg: 1.30
VOLUME:	13.6	l	

NEW SOLUTION:

H_2O:		kg
$FeCl_3$ GH_2O:		kg
NaCl:		kg
$PbCl_2$:		kg
Conc HCl:		l
:		kg

SOLIDS:

Total Concentrate:	2.30	kg	
Residue:		kg	from Test :
Solids:		kg	
Liquid:		kg	sg:
Volume:		l	

CONDITIONS:

Test Duration:	.75	hr
Temperature:	103 - 5°C	

NOTES: 90% of concentrate added at start balance added at 0.5 hour.

MASS BALANCE LEACH TEST: D1-31

(g)	IN SOLIDS	IN SOLUTION	IN TOTAL	OUT SOLIDS	OUT SOLUTION	OUT TOTAL	DIFF. IN-OUT (gain)	% △/IN
Na	-	1117	1117	-	1011	1011	106	9
Fe	397	709	1106	311	710	1021	85	8
Zn	656	234	890	249	516	765	125	14
Pb	202	170	372	3	337	340	32	9
Cu	18.4	6.1	24.5	7.9	12.3	20.2	4.3	18
Cl	-	3529	3529	-	3175	3175	354	10
S	823	-	839	684	-	-	104	12
SO_4^{2-}	-	49	-	-	152	735	-	-
Au*	1.57	-	1.57	1.44	-	1.44	0.13	8
Ag*	502	124	626	203	397	600	26	4
H_2O**	-	11.9	11.9	-	11.6	11.6	0.3	3
TOTAL**	2.3	17.7	20.0	1.3	17.5	18.6	1.2	6

* mg

** kg

SOLUTION ASSAYS TEST: D1-31

Time min.	Zn g/1	Pb g/1	Cu g/1	Fe g/1	Fe^{3+} g/1	Cl g/1	Na g/1	H+ g/1	SO_4^{2-} g/1	Ag ppm
0	17.2	12.5	0.45	52.0	-	259	82	-	3.6	9.1
5	33.0	27.8	0.75	52.5	17.20	248	-	-	11.4	26.9
10	35.8	25.1	0.84	54.3	12.20	251	-	-	11.7	27.9
30	38.3	25.1	1.04	55.2	1.30	249	-	-	11.9	29.8
35	40.2	25.8	1.01	54.3	0.46	249	-	-	12.7	32.4
40	40.1	25.5	0.97	55.2	0.16	246	-	-	12.7	32.0
45	39.8	26.0	0.95	54.8	0.09	245	78	-	11.7	30.6

SOLIDS ASSAYS:

Time min	Zn %	Pb %	Cu %	Fe %	S %	insol %	Ag ppm	Au ppm
5	23.1	0.20	0.77	22.4	-	-	-	-
10	20.8	0.16	0.77	23.0	-	-	-	-
30	17.7	0.15	0.58	23.2	-	-	-	-
35	19.2	0.27	0.63	22.7	-	-	-	-
40	19.2	0.18	0.66	23.2	-	-	-	-
Final	19.0	0.23	0.60	23.7	52.2	1.97	155	1.10
% Remain	38	1.5	43	78	83	-	40	92

SETTLING TEST 1 DATE: 12/21/84

*SLURRY SOURCE: Leach Test D1-04
SLURRY VOLUME: 1.0 l
FLOCCULANT ADDED: None
DOSAGE: None
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	0.4227	16.91
5	50	0.1899	3.798
10	50	0.0513	1.026
30	50	0.0306	0.612
60	50	0.0240	0.480
120	50	0.0198	0.396

TOTAL SOLIDS: 20.26 g
FINAL SLURRY VOLUME: 15 ml

* Slurry sample not representative.

SETTLING TEST 2 DATE: 12/21/84

SLURRY SOURCE: Leach Test D1-04
SLURRY VOLUME: 1.0 l
FLOCCULANT ADDED: Percol E-10
DOSAGE: 1 mg/l
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	2.9467	117.9
5	50	0.0725	1.450
10	50	0.0552	1.104
30	50	0.0118	0.236
60	50	0.0116	0.232

TOTAL SOLIDS: 142.37 g
FINAL SLURRY VOLUME: 160 ml

SETTLING TEST 3 DATE: 12/21/84

SLURRY SOURCE: Leach Test D1-04

SLURRY VOLUME: 1.0 l

FLOCCULANT ADDED: Percol E-10

DOSAGE: 0.5 mg/l

TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	3.0796	123.8
5	50	0.0766	1.532
10	50	0.0561	1.122
30	50	0.0384	0.766
60	50	0.0296	0.592

TOTAL SOLIDS: 152.49 g

FINAL SLURRY VOLUME: 175 ml

SETTLING TEST 4 DATE: 12/21/84

SLURRY SOURCE: Leach Test D1-04

SLURRY VOLUME: 1.0 l

FLOCCULANT ADDED: Percol E-10

DOSAGE: 0.25 mg/l

TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	3.1584	126.3
5	50	0.1266	2.532
10	50	0.0955	1.910
30	50	0.0473	0.946
60	50	0.0423	0.846

TOTAL SOLIDS: 151.15 g

FINAL SLURRY VOLUME: 180 ml

SETTLING TEST 6 DATE: 02/02/85

SLURRY SOURCE: Leach Test 02-05
SLURRY VOLUME: 1.0 1
FLOCCULANT ADDED: Percol E-10
DOSAGE: 1 mg/1
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/1)
0	25	1.0254	41.02
5	50	0.0445	0.696
10	50	0.0495	0.890
30	50	0.286	0.572
60	50	0.0301	0.602

TOTAL SOLIDS: 59.65 g
FINAL SLURRY VOLUME: 180 ml

SETTLING TEST 7 DATE: 02/02/85

SLURRY SOURCE: Leach Test D2-05
SLURRY VOLUME: 1.0 1
FLOCCULANT ADDED: Percol E-10
DOSAGE: 0.5 mg/1
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/1)
0	25	0.9924	39.40
5	50	0.0724	1.448
10	50	0.0432	0.864
30	50	0.0467	0.934
60	50	0.0611	1.222

TOTAL SOLIDS: 61.99 g
FINAL SLURRY VOLUME: 180 ml

SETTLING TEST 8 DATE: 02/02/85

SLURRY SOURCE: Leach Test D2-05
SLURRY VOLUME: 1.0 1
FLOCCULANT ADDED: Percol E-10
DOSAGE: 0.25 mg/1
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/1)
0	25	0.4241	16.96
5	50	0.0675	1.350
10	50	0.0427	0.854
30	50	0.0329	0.658
60	50	0.0247	0.494

TOTAL SOLIDS: 53.49 g
FINAL SLURRY VOLUME: 180 ml

SETTLING TEST 9 DATE: 02/05/85

SLURRY SOURCE: Leach Test D2-06
SLURRY VOLUME: 1.0 1
FLOCCULANT ADDED: None
DOSAGE: None
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/1)
0	25	1.1839	47.36
2	50	0.0409	0.818
5	50	0.0305	0.610
10	50	0.0255	0.510
30	50	0.0167	0.334
60	50	0.0268	0.536
120	50	0.0165	0.330

TOTAL SOLIDS: 73.81 g
FINAL SLURRY VOLUME: 115 ml

SETTLING TEST 10 DATE: 02/05/85

SLURRY SOURCE: Leach Test D2-06
SLURRY VOLUME: 1.0 l
FLOCCULANT ADDED: Percol E-10
DOSAGE: 0.5 mg/l
TEMPERATURE: 90°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	1.1897	47.59
2	50	0.0281	0.562
5	50	0.0162	0.324
10	50	0.0156	0.312
30	50	0.0216	0.432
60	50	0.0120	0.240

TOTAL SOLIDS: 73.36 g
FINAL SLURRY VOLUME: 125 ml

SETTLING TEST 11 DATE: 02/15/85

SLURRY SOURCE: Leach Test D2-55
SLURRY VOLUME: 1.0 l
FLOCCULANT ADDED: None
DOSAGE:
TEMPERATURE: 92°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
0	25	2.4583	98.3
5	50	0.0254	0.508
15	50	0.0524	1.048
30	50	0.0374	0.748
60	50	0.0317	0.634
60	bulk	0.4722	

TOTAL SOLIDS: 248 g
FINAL SLURRY VOLUME: 410 ml
ULTIMATE % SOLIDS: 39.7

SETTLING TEST 12 DATE: 03/07/85

SLURRY SOURCE: Leach Test D2-61
SLURRY VOLUME: 1.0 l
FLOCCULANT ADDED: Percol 156 (anionic)
DOSAGE: 1 mg/l
TEMPERATURE: 91°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
2	50	0.0544	1.088
5	50	0.0219	0.438
10	50	0.0299	0.598
15	50	0.0302	0.604
30	50	0.0159	0.318
bulk	275	0.1612	0.586

TOTAL SOLIDS: 232 g
FINAL SLURRY VOLUME: 430 ml
ULTIMATE % SOLIDS: 34.1%

SETTLING TEST 13 DATE: 03/07/85

SLURRY SOURCE: Turbo Aerater Test D7-16
SLURRY VOLUME: 0.96 l
FLOCCULANT ADDED: Percol 156
DOSAGE: 10 mg/l
TEMPERATURE: 95°C

SETTLING TIME (min)	SAMPLE VOLUME (ml)	SOLIDS WEIGHT (g)	SOLIDS DENSITY (g/l)
2	50	0.3375	6.750
5	50	0.1187	2.374
10	50	0.1582	3.164
15	50	0.119	2.238
30	50	0.1150	2.300
45	50	0.1093	2.186
60	bulk	2.8953	

TOTAL SOLIDS: 35.9 g
FINAL SLURRY VOLUME: 75 ml
ULTIMATE % SOLIDS: 27%

FILTRATION TEST: 5

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	41.0	17.0	8.70
1st WASH SOL'N	58.0	23.2	11.5
2nd WASH SOL'N	5.50	2.90	1.095
3rd WASH SOL'n	0.30	0.15	0.075
REPULP			

FILTRATION TEST: 5 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids
SLURRY WEIGHT: 0.377 kg
VOLUME: 0.250 l
% SOLIDS: 33
FABRIC: F4117

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	965	90	23	4	
1st WASH	125	105	80	25	3	1 M NaCl
2nd WASH	125	100	80	24	3	1 M NaCl
3rd WASH	125	100		21	4	Water
REPULP						

CAKE THICKNESS: 1.59 cm
CAKE % SOLIDS: 68
DRY SOLIDS WT.: 0.126 kg

FILTRATION TEST: 6

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	60.0	23.8	11.9
1st WASH SOL'N	60.0	23.6	11.7
2nd WASH SOL'N	38.0	14.35	3.45
3rd WASH SOL'n	5.50	3.05	1.14
REPULP			

FILTRATION TEST: 6 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids

SLURRY WEIGHT: 0.307 kg

VOLUME: 0.250 l

% SOLIDS: 40

FABRIC: F4117

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	91	85	23	4	
1st WASH	60	50	85	24	1.5	1 M NaCl
2nd WASH	60	50	85	25	2	1 M NaCl
3rd WASH	60	102	85	21	4	Water
REPULP						

CAKE THICKNESS: 1.66 cm

CAKE % SOLIDS: 70

DRY SOLIDS WT.: 0.124 kg

FILTRATION TEST: 7

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	45.0	16.9	8.1
1st WASH SOL'N	21.0	7.8	3.9
2nd WASH SOL'N	1.80	0.695	0.97
3rd WASH SOL'n	1.25	0.080	0.12
REPULP			

FILTRATION TEST: 7 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids
SLURRY WEIGHT: 0.176 kg
VOLUME: 0.125 l
% SOLIDS: 34
FABRIC: F4117

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITIO
FILTRATION	125	71		25	2.5	
1st WASH	125	109		24	3.0	1 M NaCl
2nd WASH	125	119		25	2.5	1 M NaCl
3rd WASH	125	155		10	5.0	Water
REPULP						

CAKE THICKNESS: 0.58 cm
CAKE % SOLIDS: 69
DRY SOLIDS WT.: 0.059 kg

FILTRATION TEST: 8

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	59.0	21.4	11.3
1st WASH SOL'N	46.0	16.8	8.1
2nd WASH SOL'N	13.50	6.20	1.42
3rd WASH SOL'n	1.90	0.80	0.70
REPULP			

FILTRATION TEST: 8

DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids
SLURRY WEIGHT: 0.191 kg
VOLUME: 0.125 l
% SOLIDS: 33
FABRIC: F4117

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	54	90	24	1.5	
1st WASH	60	42		25	1.5	1 M NaCl
2nd WASH	60	55		26	1.5	1 M NaCl
3rd WASH	60	94		10	1.5	Water
REPULP						

CAKE THICKNESS: 0.77 cm
CAKE % SOLIDS: 68
DRY SOLIDS WT.: 0.062 kg

FILTRATION TEST: 9

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	43.0	18.6	9.10
1st WASH SOL'N	35.0	15.1	8.80
2nd WASH SOL'N	3.05	1.29	0.65
3rd WASH SOL'n	0.25	0.14	0.08
REPULP			

FILTRATION TEST: 9 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids
SLURRY WEIGHT: 0.360 kg
VOLUME: 0.250 l
% SOLIDS: 44
FABRIC: F4117

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	142		22	5.0	
1st WASH	125	111		24	3.5	1 M NaCl
2nd WASH	125	116		23	3.5	1 M NaCl
3rd WASH	125	169		7	8.5	Water
REPULP						

CAKE THICKNESS: 1.51 cm
CAKE % SOLIDS: 60
DRY SOLIDS WT.: 0.160 kg

FILTRATION TEST: 10

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE		11.5	5.9
1st WASH SOL'N	13.0	5.4	2.7
2nd WASH SOL'N	0.75	0.36	0.29
3rd WASH SOL'n	0.10	0.52	0.04
REPULP			

FILTRATION TEST: 10 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids

SLURRY WEIGHT: 0.162 kg

VOLUME: 0.125 l

% SOLIDS: 30

FABRIC: S 4058

	VOLUME (ml) IN	 OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	72		30	2	
1st WASH	125	118		26	2.5	1 M NaCl
2nd WASH	125	110		26	2.5	1 M NaCl
3rd WASH	125	152		4	6	Water
REPULP						

CAKE THICKNESS: 0.55 cm

CAKE % SOLIDS: 67

DRY SOLIDS WT.: 0.037 kg

FILTRATION TEST: 11

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE		11.3	5.5
1st WASH SOL'N	15.0	6.1	3.3
2nd WASH SOL'N	4.25	1.80	1.02
3rd WASH SOL'n	0.35	0.21	0.26
REPULP			

FILTRATION TEST: 11 DATE: 01/05/85

SLURRY SOURCE: D2-06 Settled Solids
SLURRY WEIGHT: 0.156 kg
VOLUME: 0.125 l
% SOLIDS: 22
FABRIC: S 4058

	VOLUME (ml) IN	 OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	97		25	2.6	
1st WASH	60	63		25	1.6	1 M NaCl
2nd WASH	60	48		25	1.0	1 M NaCl
3rd WASH	60	91		4	4.0	Water
REPULP						

CAKE THICKNESS: 0.59 cm
CAKE % SOLIDS: 67
DRY SOLIDS WT.: 0.034 kg

FILTRATION TEST: 12

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	47.0	13.6	
1st WASH SOL'N	37.5	10.3	
2nd WASH SOL'N	9.80	3.78	
3rd WASH SOL'n	0.88	0.22	
REPULP	0.47	0.131	

FILTRATION TEST: 12 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.374 kg
VOLUME: 0.250 l
% SOLIDS: 32
FABRIC: S 4058

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	96	90	23	3.5	
1st WASH	125	119	80	24	4.0	1 M NaCl
2nd WASH	125	116	80	23	3.0	1 M NaCl
3rd WASH	125	118	80	23	3.0	Water
REPULP	500					Water

CAKE THICKNESS: 1.75 cm
CAKE % SOLIDS: 69
DRY SOLIDS WT.: 0.119 kg

FILTRATION TEST: 13

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	38.5	11.1	
1st WASH SOL'N	28.0	8.05	
2nd WASH SOL'N	4.68	1.50	
3rd WASH SOL'n	2.13	0.67	
REPULP	0.73	0.21	

FILTRATION TEST: 13 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.359 kg
VOLUME: 0.250 l
% SOLIDS: 32
FABRIC: S 4058

	VOLUME (ml) IN	 OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	102	85	24	3	
1st WASH	60	62	90	25	3	1 M NaCl
2nd WASH	60	57	85	25	1.5	1 M NaCl
3rd WASH	60	62	85	25	2	Water
REPULP	500					Water

CAKE THICKNESS: 1.72 cm
CAKE % SOLIDS: 68
DRY SOLIDS WT.: 0.114 kg

FILTRATION TEST: 14

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	40.0	11.2	
1st WASH SOL'N	21.0	6.15	
2nd WASH SOL'N	0.99	0.42	
3rd WASH SOL'n	0.13	0.04	
REPULP	0.21	0.07	

FILTRATION TEST: 14 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.180 kg
VOLUME: 0.125 l
% SOLIDS: 31
FABRIC: S 4058

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	54	85	24	1.5	
1st WASH	125	125	80	25	3	1 M NaCl
2nd WASH	125	125	80	25	2.5	1 M NaCl
3rd WASH	125	125	80	24	3	Water
REPULP	500					Water

CAKE THICKNESS: 0.64 cm
CAKE % SOLIDS: 73
DRY SOLIDS WT.: 0.056 kg

FILTRATION TEST: 15

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	40.5	11.90	
1st WASH SOL'N	33.0	9.15	
2nd WASH SOL'N	21.0	6.15	
3rd WASH SOL'n	1.20	0.65	
REPULP	0.16	0.004	

FILTRATION TEST: 15 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.204 kg
VOLUME: 0.125 l
% SOLIDS: 32
FABRIC: S 4058

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	58	90	25	2.0	
1st WASH	60	58	85	25	1.5	1 M NaCl
2nd WASH	60	70	85	24	2.0	1 M NaCl
3rd WASH	60	53	80	24	1.5	Water
REPULP	500					Water

CAKE THICKNESS: 0.76 cm
CAKE % SOLIDS: 72
DRY SOLIDS WT.: 0.065 kg

FILTRATION TEST: 16

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	35.5	10.1	
1st WASH SOL'N	32.0	8.8	
2nd WASH SOL'N	8.0	3.0	
3rd WASH SOL'n	0.86	0.17	
REPULP	0.12	0.04	

FILTRATION TEST: 16 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.350 kg
VOLUME: 0.250 l
% SOLIDS: 26
FABRIC: 4511

	VOLUME (ml) IN	 OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	110	80	25	3.0	
1st WASH	125	83		24	3.0	1 M NaCl
2nd WASH	125	108		24	4.5	1 M NaCl
3rd WASH	125	100		24	3.5	Water
REPULP	500					Water

CAKE THICKNESS: 0.13 cm
CAKE % SOLIDS: 62
DRY SOLIDS WT.: 0.91 kg

FILTRATION TEST: 17

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	41.5	12.1	
1st WASH SOL'N	36.5	10.4	
2nd WASH SOL'N	29.0	8.53	
3rd WASH SOL'n	4.10	1.25	
REPULP	0.86	0.25	

FILTRATION TEST: 17 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.351 kg
VOLUME: 0.250 l
% SOLIDS: 30
FABRIC: 4511

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	250	77	80	24	3	
1st WASH	60	59		25	1.5	1 M NaCl
2nd WASH	60	45		26	1.5	1 M NaCl
3rd WASH	60	56		25	1.5	Water
REPULP	500					Water

CAKE THICKNESS: 0.15 cm
CAKE % SOLIDS: 63
DRY SOLIDS WT.: 0.112 kg

FILTRATION TEST: 18

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	50.0	13.6	
1st WASH SOL'N	52.0	14.7	
2nd WASH SOL'N	18.5	5.13	
3rd WASH SOL'n	0.95	0.34	
REPULP	0.05	0.02	

FILTRATION TEST: 18 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.173 kg
VOLUME: 0.125 l
% SOLIDS: 30
FABRIC: 4511

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	19	90	25	1	
1st WASH	125	115	85	26	2.5	1 M NaCl
2nd WASH	125	109	85	24	2.5	1 M NaCl
3rd WASH	125	113	85	24	2	Water
REPULP	500					Water

CAKE THICKNESS: 0.85 cm
CAKE % SOLIDS: 63
DRY SOLIDS WT.: 0.054 kg

FILTRATION TEST: 19

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	61	17.2	
1st WASH SOL'N	62	17.3	
2nd WASH SOL'N	36.8	11.53	
3rd WASH SOL'n	7.50	2.25	
REPULP	0.54	0.161	

FILTRATION TEST: 19 DATE: 01/10/85

SLURRY SOURCE: D2-08 Settled Solids
SLURRY WEIGHT: 0.191 kg
VOLUME: 0.125 l
% SOLIDS: 30
FABRIC: 4511

	VOLUME (ml) IN	OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	125	41	90	25	2	
1st WASH	60	69	90	25	2	1 M NaCl
2nd WASH	60	56	85	25	2	1 M NaCl
3rd WASH	60	60	85	25	2	Water
REPULP	500					Water

CAKE THICKNESS: 0.87 cm
CAKE % SOLIDS: 62
DRY SOLIDS WT.: 0.059 kg

FILTRATION TEST: 20

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	53.7	17.7	3.2
1st WASH SOL'N	55.1	17.9	3.1
2nd WASH SOL'N	65.3	24.4	4.5
3rd WASH SOL'n	3.5	1.4	0.3
REPULP		0.6	0.5

FILTRATION TEST: 20 DATE: 02/15/85

SLURRY SOURCE: D2-55 Settled Solids
SLURRY WEIGHT: 0.727 kg
VOLUME: 0.500 l
% SOLIDS: 42
FABRIC: S 4058

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	500	157	92	4	4.5	
1st WASH	250	288	85	20	7+30	1 M NaCl
2nd WASH	250	264	85	20	9+30	2 M NaCl
3rd WASH	250	250	95	20	7+60	Water
REPULP	500					Water

CAKE THICKNESS: 3.5 cm
CAKE % SOLIDS: 74
DRY SOLIDS WT.: 0.309 kg

FILTRATION TEST: 21

		(g/l)	
ASSAY	Fe	Zn	Pb
FILTRATE	53.9	17.9	3.3
1st WASH SOL'N	25.0	8.6	1.98
2nd WASH SOL'N	1.47	0.45	0.08
3rd WASH SOL'n	0.14	0.05	0.15
REPULP	1.3	0.40	0.10

FILTRATION TEST: 21 DATE: 02/15/84

SLURRY SOURCE: D2-55 Settled Solids

SLURRY WEIGHT: 0.739 kg

VOLUME: 0.500 l

% SOLIDS: 31

FABRIC: S 4058

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	500	195	92	21	4.5	
1st WASH	250	290	95	20	9+30	Water
2nd WASH	250	245	95	20	5.5+30	Water
3rd WASH	250	250	95		6.5+60	Water
REPULP						Water

CAKE THICKNESS: 3.0 cm

CAKE % SOLIDS: 61

DRY SOLIDS WT.: 0.229 kg

FILTRATION TEST: 22

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	48.9	18.1	13.3
1st WASH SOL'N	37.9	16.5	
2nd WASH SOL'N	11.2	4.2	
3rd WASH SOL'n	0.6	0.2	
REPULP	0	0	

FILTRATION TEST: 22 DATE: Mar. 7/85

SLURRY SOURCE: D2-61
SLURRY WEIGHT: 0.731 kg
VOLUME: 0.500 l
% SOLIDS: 35.6
FABRIC: S 4058

	VOLUME (ml) IN	OUT	TEMP. (0°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	500	185	95	18	7.0	-
1st WASH	200	198	95	20	7.5	1M NaCl
2nd WASH	200	197	95	19.5	6.0	1M NaCl
3rd WASH	200	266	95	20	5.8+60	H_2O
REPULP	500	-	95	-	-	H_2O

CAKE THICKNESS: 2.7 cm
CAKE % SOLIDS: 73.2
DRY SOLIDS WT.: 0.260 kg

FILTRATION TEST: 23

ASSAY	Fe	(g/l) Zn	Pb
FILTRATE	48.6	18.7	13.3
1st WASH SOL'N	39.1	16.4	
2nd WASH SOL'N	13.9	6.3	
3rd WASH SOL'n	1.2	0.3	
REPULP	0	0	

FILTRATION TEST: 23 DATE: Mar. 7/85

SLURRY SOURCE: D2-61
SLURRY WEIGHT: 0.757 kg
VOLUME: 0.500 l
% SOLIDS: 34.9
FABRIC: S 4058

	VOLUME (ml) IN	VOLUME (ml) OUT	TEMP. (0°C)	VACUUM (in HG)	TIME (s)	WASH COMPOSITION
FILTRATION	500	155	95	17	7.0	-
1st WASH	200	195	95	19	8.0	5% HCl
2nd WASH	200	205	95	19.5	6.8	H_2O
3rd WASH	200	325	95	19.5	5.5+60	H_2O
REPULP	500	-	95	-	-	H_2O

CAKE THICKNESS: 2.9 cm
CAKE % SOLIDS: 75.6
DRY SOLIDS WT.: 0.264 kg

COLUMN CHLORINATION RESULTS

TEST	DATE	SOL'N FROM TEST	SOL'N FLOW (ml/min)	Cl_2 FLOW (ml/min)	TOTAL Fe (g/l)	Fe^{2+} IN (g/l)	Fe^{2+} OUT (g/l)
10	1/23	D2-13	100	1100	53.3	45.4	20.9
11	1/29	D2-15	100	1500	51.9	39.2	0
12	1/31	D2-16	100	1500	44.4	38.8	0
13	2/5	D2-18	100	1500	49.8	42.9	0
14	2/7	D2-20	100	1500	51.8	44.5	1.6
16	2/18	D2-22	100	1500	52.4	36.4	0
17	2/20	D2-23	125	1800	51.2	36.4	2.2
18	2/21	D2-24	125	1800	54.2	45.3	0
19	2/25	D2-25	125	1800	51.9	42.1	0.8
20	2/27	D2-26	125	1800	53.0	48.1	<1
21	3/4	D2-27	125	1800	52.4	43.2	0

TANK CHLORINATION: D3-22 DATE: 03/08/85

SOLUTION FROM TEST: D2-28
SOLUTION WEIGHT: 9.37 kg sg: 1.28
VOLUME: 7.29

TIME (min)	Cl_2 FLOW (ml/min)	SOL'N TEMP (°C)	TOTAL Fe (g/l)	Fe^{3+} (g/l)
0		95	52.3	<1
15	1800	106	53.1	25.4
30	1800	109*	52.2	31.3
45	1800	109*	51.2	42.9
60	1800	106	52.4	58.3

* Solution was boiling.

TANK CHLORINATION: D3-23 DATE: 03/08/85

SOLUTION FROM TEST: D3-28
SOLUTION WEIGHT: 8.60 kg sg: 1.28
VOLUME: 6.72 l

TIME (min)	Cl_2 FLOW (ml/min)	SOL'N TEMP (^{o}C)	TOTAL Fe (g/l)	Fe^{3+} (g/l)
0		55	51.7	< 1
15	3500	69	51.2	37.3
30	3500	74		56

TANK CHLORINATION: D3-24 DATE: 03/08/85

SOLUTION FROM TEST: D2-29
SOLUTION WEIGHT: 17.96 kg sg: 1.29
VOLUME: 13.94 l

TIME (min)	Cl_2 FLOW (ml/min)	SOL'N TEMP (^{o}C)	TOTAL Fe (g/l)	Fe^{3+} (g/l)
0		75	52.4	10
10	4800	78		25
20	4800	80		35
30	4800	82		46
40	4800	84		55

TANK CHLORINATION: D3-25 DATE: 03/26/85

SOLUTION FROM TEST: D2-30

SOLUTION WEIGHT: 17.8 kg sg: 1.29

VOLUME: 13.8 l

TIME (min)	Cl_2 FLOW (ml/min)	SOL'N TEMP (0°C)	Fe^{3+} (g/l)
0	6800	80	12.1
3	6800	81	17.6
6	6800	83	22.4
9	6800	84	27.2
12	6800	84	32.6
15	6800	86	37.8
18	6800	85	43.1
21	6800	86	48.3
24	6800	87	47.3
27	6800	87	50.0

CEMENTATION TEST: D4-16 DATE: 03/12/85

SOLUTION FROM TEST: D1-30
SOLUTION WEIGHT: 17.0 kg sg: 1.35
VOLUME: 12.6 l

	Pb	Pb	SOLUTION			
TIME (min)	ADDED (g)	ACCUM (g)	Ag (ppm)	Cu (g/l)	Fe^{3+} (g/l)	Pb (g/l)
0			30.8	0.78	< 1	25.9
15	16	16	27.6	0.78	0.7	27.2
30	16	32	10.9	0.70	< .7	28.7
45	16	48	2.0	0.51	0.5	29.4
60	16	64	1.2	0.30	< .5	31.3
75	16	72	0.6	0.10	< .5	32.0

INITIAL SOLUTION:

Zn (g/l)	Na (g/l)	Fe (g/l)	SO_4^{2-} (g/l)	Cl (g/l)
45.1	80.6	57.4	13.1	273

CEMENTATION TEST: D4-10 DATE: 02/25/85

SOLUTION FROM TEST: D1-20
SOLUTION WEIGHT: 1.29 kg sg: 1.29
VOLUME: 1.00 l

	Pb	Pb	SOLUTION			
TIME (min)	ADDED (g)	ACCUM (g)	Ag (ppm)	Cu (g/l)	Fe^{3+} (g/l)	Pb (g/l)
0			22.4	0.45	1.7	26.7
15	2.0	2.0	22.0	0.46	1.3	30.8
30	2.0	4.0	2.7	0.36	< 2	31.5
45	2.0	6.0	0.2	0.06	< 1	34.1
60	2.0	8.0	0.7	0.09	< .5	34.8
75	2.0	10.0	0.3	0.11	< .5	39.3

INITIAL SOLUTION:

Zn (g/l)	Na (g/l)	Fe (g/l)	SO_4^{2-} (g/l)	Cl (g/l)
26.6	71	57.8	9.81	224

CEMENTATION TEST: D4-18 DATE: Mar. 26/85
Solution from Test: D1-31
Solution Weight: 2.70 kg sg: 1.348
Volume: 2.00 l

Time (min)	Pb added (g)	Pb accum. (g)	Solution Assay Ag(ppm)	Solution Assay Cu(g/l)	Solution Assay Fe^{3+}(g/l)
0	-	0	32.08	.978	.298
15	10	10	0.60	.027	.091
30	-	10	0.68	.033	<.04
40	5	15	N/A	N/A	N/A
45	-	15	0.84	.009	<.04
60	-	15	0.84	.024	<.04

Initial Solution:

Zn (g/l)	Pb (g/l)	Fe (g/l)	SO_4^{2-} (g/l)	Cl (g/l)	Na (g/l)
39.8	26.0	54.8	11.7	259	78

CEMENTATION TEST: D4-17 DATE: Mar. 26/85
Solution from Test: D1-31
Solution Weight: 2.70 kg sg: 1.348
Volume: 2.00 l

Time (min)	Pb added (g)	Pb accum (g)	Solution Assay Ag(ppm)	Solution Assay Cu(g/l)	Solution Assay Fe^{3+}(g/l)
0	0	-	32.2	.818	.435
15	4.0	4.0	27.7	.839	.228
30	4.0	8.0	15.5	.827	.109
45	4.0	12.0	6.7	.646	.082
60	4.0	16.0	0.8	.034	.090
75	4.0	20.0	0.5	.005	<.04

NOTES: 5.76 g Antimony Potassium Tartrate added at start
(1 g/l Sb).

Initial Solution:

Zn (g/l)	Pb (g/l)	Fe (g/l)	SO_4^{2-} (g/l)	Cl (g/l)	Na (g/l)
39.8	26.0	54.8	11.7	259	78

CEMENTATION TEST: D4-19
Solution from Test: D1-31
Solution Weight: 2.70 kg sg: 1.348
Volume: 2.00 l

DATE: Mar. 26/85

Time (min)	Pb added (g)	Pb accum (g)	Solution Assay Ag(ppm)	Cu(g/l)	Fe^{3+}(g/l)
0	-	-			
15	10	10	-	.933	-
30	-	10	-	.083	-
45	5	15	-	.109	-
			-	.031	-

NOTES: 5.0 Hydrazine HCl added at start
Solution Assay for copper only.

Initial Solution:

Zn (g/l)	Pb (g/l)	Fe (g/l)	SO_4^{2-} (g/l)	Cl (g/l)	Na (g/l)
39.8	26.0	54.8	11.7	259	78

CEMENTATION TEST: D4-20
Solution from Test: D4-19
Solution Weight: 2.70 kg sg: 1.348
Volume: 2.00 l

DATE: Mar. 27/85

Time (min)	Pb added (g)	Pb accum (g)	Solution Assay Ag(ppm)	Cu(g/l)	Fe^{3+}(g/l)
0	-	0	-	.030	-
15	5	5	-	.014	-
30	-	5	-	.008	-
45	-	5	-	.010	-

NOTES: Solution stirred at minimal rate of 40 rpm.
Solution assay for copper only.

$PbCl_2$ CRYSTALLIZATION TEST: D5-11 DATE: 01/23/85

SOLUTION FROM TEST: D1-13

VESSEL: 1 l Crystallizer

TEMPERATURE: 86 ⟶ 10 ⟶ 80°C

Temp. (°C)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	Fe (g/l)
86	23.0	47	1.0	68	239	57
10	6.2					
15	6.6					
25	8.1					
30	6.8					
40	10.2					
50	12.1					
60	14.5					
70	16.7					
80	20.4	47	1.0	63	233	56

$PbCl_2$ CRYSTALLIZATION TEST: D5-12 DATE: 01/23/85

SOLUTION FROM TEST: D1-10

VESSEL: 1 l Crystallizer

1. Bulk solution heated to 95°C; crystallizer filled, solution cooled from 95°C to 20°C as quickly as possible (~ 30 min). Crystals washed twice with 100 ml sat'd $PbCl_2$ @ 20°C and then with ethanol.

2. As 1. except crystals held at 20°C for 30 min.
3. As 1. except crystals held at 20°C for 60 min.

$PbCl_2$ SCREEN ANALYSIS (mesh)	1. (%)	2. (%)	3. (%)
+ 65	0.1	0.2	0.9
- 65 +100	0.3	0.5	2.0
-100 +150	0.3	1.0	3.0
-150 +200	1.4	1.7	4.7
-200 +325	4.8	2.3	10.8
-325 +400	2.5	2.4	15.7
-400	90.6	90.1	63.1
SO_4^{2-} (%)	0.64	0.57	0.51

$PbCl_2$ CRYSTALLIZATION TEST: D5-13 DATE: 01/24/85

SOLUTION FROM TEST: D1-13

VESSEL: 1 l Crystallizer

1. Bulk solution heated to 95°C, crystallizer filled, solution cooled from 95° to 20°C as rapidly as possible (3°C/min). Crystals washed twice with 100 ml sat'd $PbCl_2$ @ 20°C and then with ethanol.

2. As 1. except the cooling rate was 2°C/min.

3. As 1. except the cooling rate was 1.5°C/min.

$PbCl_2$ SCREEN ANALYSIS (mesh)	1. (%)	2. (%)	3. (%)
+ 65	0.4	0.5	0.4
- 65 +100	0.7	0.3	0.9
-100 +150	1.8	0.8	2.8
-150 +200	5.1	1.1	5.3
-200 +325	12.9	2.9	20.6
-325 +400	9.7	5.8	9.4
-400	69.5	88.5	60.7
SO_4^{2-} (%)	0.51	0.47	0.46

$PbCl_2$ CRYSTALLIZATION TEST: D5-14 DATE: 01/28/85

SOLUTION FROM TEST: D1-13

VESSEL: 1 l Crystallizer

1. Bulk solution heated to 90°C and 1.07 l was pumped through the heat exchanger, cooling it to 40°C. When the vessel was filled, the crystals were held at 40°C for 30 min. Crystals washed twice with 100 ml sat'd $PbCl_2$ @ 40°C and then with ethanol.

2. As 1. except the crystal slurry was cooled to 20°C and held there for 30 min after the crystallizer was filled.

SOLUTION COMPOSITIONS

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Cl (g/l)	Fe (g/l)
Feed	27.0	5.0	1.1	271	58
After 1.	13.2				
After 2	9.3				

$PbCl_2$ SCREEN ANALYSIS (mesh)	1. (%)	2. (%)
+ 65	0.1	0.2
- 65 +100	0.1	0.7
-100 +150	0.4	0.9
-150 +200	2.4	1.1
-200 +325	9.7	3.9
-325 +400	6.5	3.6
-400	80.8	89.5
SO_4^{2-} (%)	0.61	0.50

$PbCl_2$ CRYSTALLIZATION TEST: D5-15 DATE: 02/02/85

SOLUTION FROM TEST: D1-16
VESSEL: Leach Tank

18 kg of leach solution cooled from 90 to 5° in 60 min.

$PbCl_2$ SCREEN ANALYSIS

(mesh)	(%)
+ 65	0.1
- 65 +100	0.4
-100 +150	1.2
-150 +200	4.9
-200 +325	18.3
-325 +400	8.1
-400	67.0
SO_4^{2-} (%)	0.52

$PbCl_2$ CRYSTALLIZATION TEST: D5-16 DATE: 02/02/85

SOLUTION FROM TEST: D1-16
VESSEL: Leach Tank

18 kg of solution cooled from 100 to 15°C at 20°C/hr.

$PbCl_2$ SCREEN ANALYSIS

(mesh)	(%)
+ 65	3.1
- 65 +100	9.3
-100 +150	13.2
-150 +200	26.7
-200 +325	23.6
-325 +400	5.0
-400	19.0
SO_4^{2-} (%)	0.59

$PbCl_2$ CRYSTALLIZATION TEST: D5-17 DATE: 02/11/85

SOLUTION FROM TEST: D1-10

VESSEL: Leach Tank

Solution heated to 100°C and pumped through the heat exchanger where it was cooled to 40°C. Leach tank filled with 40°C solution and cooled from 40 to 10°C in 60 min.

SOLUTION COMPOSITIONS

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)
Feed	19.7	53.5	1.33	75	296
Cooled Sol'n	7.8	51.1	1.28		275

$PbCl_2$ SCREEN ANALYSIS

(mesh)	(%)
+ 65	3.8
- 65 +100	5.6
-100 +150	14.8
-150 +200	30.6
-200 +325	25.8
-325 +400	5.9
-400	13.5
SO_4^{2-} (%)	0.52

$PbCl_2$ Screen Analysis: D5-21

Mesh	%
+ 65	15.2
-65 + 100	9.6
-100 + 150	10.1
-150 + 200	13.6
-200 + 325	18.9
-325 + 400	3.0
-400	30.4

$PbCl_2$ CRYSTALLIZATION TEST: D5-22
Solution from Test: D4-12
Solution Weight: 16.3 kg sg: 1.33 kg/l
Volume: 12.3 l

Vessel: Leach Tank
Temperature Cycle: 100 - 40°C ½ hour
40 - 15°C 2.0 hour
Filtrate Weight: 15.6 kg sg: 1.32
Volume: 11.8 l
$PbCl_2$ Crystal Weight: .356 kg

SOLUTION COMPOSITIONS

	Zn g/l	Pb g/l	Cu g/l	Fe g/l	Na g/l	Cl^- g/l	SO_4^{2-} g/l	Ag ppm	H+ ppm
Feed	44.0	30.1	0.96	57.2	70	251	8.9	9.32	12.5
Crys. Out	50.8	7.8	1.03	59.1	73	254	9.5	9.20	14.7

$PbCl_2$ CRYSTALLIZATION TEST: D5-23

SOLUTION FROM TEST: D4-13
SOLUTION WEIGHT: 15.5 kg sg: 1.35
VOLUME: 11.5

VESSEL: Leach tank
TEMPERATURE CYCLE: 100 40°C ½hr.
: 40 15°C 2½hr.
FILTRATE WEIGHT: 14.7 kg sg: 1.33
VOLUME: 11.1 l
$PbCl_2$ CRYSTALS: .378 kg

SOLUTION COMPOSITIONS:

	Zn (g/l)	Pb (g/l)	Cu (g/l)	Fe (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)	HCl (g/l)
Feed	55.0	34.0	0.98	60.3	65	264	10.2	4.1	11.7
Crys.out	60.5	8.0	1.00	62.8	73	263	10.7	3.9	12.1
Wash 1	41.5	4.5	-	-	-	-	-	-	-
Wash 2	3.5	2.1	-	-	-	-	-	-	-
Wash 3	0.4	2.5	-	-	-	-	-	-	-

SOLID COMPOSTIONS:

Time	Zu %	Pb %	Cu %	Fe %	Na %	SO_4^{2-} %
Final	.006	-	-	<.002	0.5	.06

$PbCl_2$ CRYSTALLIZATION TEST: D5-24 to D5-28
Solution from Test: D4-14 and D4-15
Solution Weight: 1.36 kg sg: 1.36
Solution Volume: 1.00 l

Vessel: 1 l.crystallizer
Temperature Cycle: 95 - 15°C ½ hour.

Test#	Precipitant Type	Precipitant conc. (g/l)	Soln. Pb (g/l)	Soln. SO_4 (g/l)
D5-24	$CaCl_2$	20	16.9	8.51
D5-25	-	-	29.0	12.90
D5-26	$BaCl_2$	30	29.9	1.11
D5-27	$CaCl_2$	16	26.0	10.84
D5-28	$BaCl_2$	15	21.1	8.43

Test #	Filtrate wt. (Kg)	Filtrate Vol. (l)	$PbCl_2$ wt. (g)	% SO_4^{2-} in $PbCl_2$
D5-24	1.26	.87	15.2	3.14
D5-25	-	-	-	0.17
D5-26	1.20	.85	15.0	0.09
D5-27	1.20	.90	14.7	20.97
D5-28	1.29	.96	13.9	0.06

$PbCl_2$ CRYSTALLIZATION TEST: D5-29
Solution from Test: D4-16
Solution Weight: 16.2 kg sg: 1.36
Volume: 11.9 l

Vessel: Leach Tank
Temperature Cycle: 95 - 50°C .25 Hour
50 - 10°C 2.5 Hour
Filtrate Weight: 15.2 kg sg: 1.35
Volume: 11.3 l
$PbCl_2$ Crystal wt: .381 kg

SOLUTION COMPOSITIONS

Sample #	Temperature °C	$PbCl_2$ Crystals % Weight
D5-2901	50	1.18
D5-2902	30	2.00
D5-2903	20	2.29
D5-2904	15	2.46
D5-2905	10	2.42

SOLUTION ASSAY (g/l):

Sample #	Cu	Pb	Zn	Na	Cl^-	SO_4	Fe+
D5-2901	.124	15.5	48.0	82	251	-	59.5
D5-2902	.125	11.0	49.7	85	-	-	-
D5-2903	.116	9.6	49.6	86	-	-	-
D5-2904	.122	8.9	48.4	83	-	-	-
D5-2905	.119	9.1	48.1	89	-	13.4	59.4

$PbCl_2$ CRYSTALLIZATION TEST: D5-29

SOLID COMPOSITIONS/ASSAYS:

Sample #	Zu %	Pb %	Cu %	Fe %	Na %	Cl^- %	SO_4^{2-} %
D5-2901	0.30	-	.0030	.364	0.52	24.0	0.13
D5-2902	0.35	-	.0014	.424	0.60	25.2	0.15
D5-2903	0.43	-	.0014	.494	0.72	25.4	0.37
D5-2904	0.46	-	.0014	.522	0.78	25.7	0.19
D5-2905	0.37	-	.0014	.432	0.60	25.2	0.21

$PbCl_2$ SCREEN ANALYSIS: D5-29B

Mesh	%
+ 65	1.7
- 65 + 100	4.6
-100 + 150	9.0
-150 + 200	19.0
-200 + 325	33.0
-325 + 400	5.7
-400	27.0

SOLVENT EXTRACTION TEST: D6-09 DATE: 02/19/85

SOLUTION FROM TEST: D5-18
SOLUTION WEIGHT: 15.0 kg sg:1.33
VOLUME: 11.3 1

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3	2½/1	85/35
SCRUB			
STRIP	4	2/1	85/43

DISTRIBUTION AT 240 min:

	1A	2A	3A	30	4A	5A	6A	7A	70
Zn (g/l)	14.3	22.6	36.7	25.5	42.9	41.9	33.4	25.3	11.0

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED	10.2	49.7	0.92	61.5		85	270	11.3	13.3	35.7
BARREN SOL/N	9.0	12.7	0.16	62.4	7.3	76	200	0	12.7	28.8
LOADED STRIP	0.3	41.6	0.82	3.2	0	2	79	21	0.8	1.2
STRIP FEED		14.6								

SOLVENT EXTRACTION TEST: D6-10 DATE: 02/21/85

SOLUTION FROM TEST: D5-19
SOLUTION WEIGHT: 10.9 kg sg:1.34
VOLUME: 8.13 1

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3	2½/1	85/35
SCRUB			
STRIP	4	2/1	85/43

DISTRIBUTION AT 240 min:

	1A	2A	3A	30	4A	5A	6A	7A	70
Zn (g/l)	17.8	27.8	42.3	28.5	40.7	40.6	33.7	24.6	14.5
Pb (g/l)	10.7		10.2	2.75	1.4			<0.1	2.5
Fe (g/l)	64.3		66.2	28.0	10.4			<0.1	3.8

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED	9.3	54.8	1.02	65.2	58.2	74	275	10.7	4.5	13.9
BARREN SOL/N	9.4	16.4	0.10	64.8	59.2	75	212	0	5.3	11.8
LOADED STRIP	1.3	41.7	0.75	7.6	4.5	9	98	28.3	0.8	2.0
STRIP FEED		14.6								

SOLVENT EXTRACTION TEST: D6-11 DATE: 02/24/85

SOLUTION FROM TEST: D5-20
SOLUTION WEIGHT: 14.9 kg sg:1.32
VOLUME: 11.3 l

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3	2½/1	85/35
SCRUB			
STRIP	4	2/1	85/43

DISTRIBUTION AT 240 min:

	1A	2A	3A	30	4A	5A	6A	7A	70
Zn (g/l)	17.5	28.0	41.4	25.5	43.5	40.3	32.6	23.7	13.0
Pb (g/l)	7.5		7.6	1.8	0.6			<0.1	1.8
Fe (g/l)	57.7		61.7	7.8	3.5			0.3	3.3

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED	7.5	53.5	0.91	58.7	54.9	75	252	6.8	11.9	9.1
BARREN SOL/N	7.6	18.1	0.10	58.0	55.7	75	202	0	12.3	9.4
LOADED STRIP	0.5	42.3	0.73	3.8	2.3	3	83	23.6	0.6	0.5
STRIP FEED		14.6								

SOLVENT EXTRACTION TEST: D6-12 DATE: 02/27/85

SOLUTION FROM TEST: D5-21
SOLUTION WEIGHT: 15.0 kg sg:1.34
VOLUME: 11.2 l

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3*	2½/1	85/35
SCRUB			
STRIP	5	2/1	85/43

DISTRIBUTION AT 240 min:

	1A	2A	3A	30	4A	5A	6A	7A	8A	80
Zn (g/l)	19.0	30.4	44.4	26.3	44.3	38.6	32.3	25.0	20.7	11.5
Pb (g/l)	10.0		10.0	1.5	0.4				<0.1	1.5
Fe (g/l)	63.7		66.4	6.5	3.8				<0.1	3.3

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED	9.2	54.0	0.72	63.7	60.3	83.0	260	2.6	12.2	7.8
BARREN SOL/N	9.7	18.7	0.04	58.1	55.1	82.0	208	0	13.5	8.6
LOADED STRIP	0.2	40.3	0.58	2.3	1.3	1.0	77	22.5	0.4	<.1
STRIP FEED		14.7								

* Extra settler added to 3rd stage.

SOLVENT EXTRACTION TEST: D6-13 DATE: 03/01/85

SOLUTION FROM TEST: D5-22
SOLUTION WEIGHT: 15.6 kg sg:1.32
VOLUME: 11.8 l

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3	2½/1	85/35
SCRUB	1	5/1	85/14
STRIP	5	2/1	85/43

DISTRIBUTION AT 240 min:

	1A	3A	30	4A	5A	9A	90
Zn (g/l)	18.7	42.3	26.3	38.6	39.1	20.0	15.5
Pb (g/l)	7.7	8.2	1.8	4.4	0.7	<0.1	1.3
Fe (g/l)	57.7	60.8	1.0	25.1	4.0	<0.1	1.8

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED										
BARREN SOL/N										
LOADED STRIP										
STRIP FEED										

SOLVENT EXTRACTION TEST: D6-14 DATE: 03/06/85

SOLUTION FROM TEST: D5-23
SOLUTION WEIGHT: 15.9 kg sg:1.27
VOLUME: 12.5 l

SX CONFIGURATION:

	STAGES	O/A	FLOW (ml/min)
EXTRACTION	3	2½/1	85/34
SCRUB	1	5/1	85/14
STRIP	5	2½/1	85/34

DISTRIBUTION AT 240 min:

	1A	3A	30	4A	5A	9A	90
Zn (g/l)	12.2	32.4	24.5	45.3	47.5	20.9	9.5
Pb (g/l)	6.0	7.0	1.8	0.5	<0.1	<0.1	0.8
Fe (g/l)	51.4	51.9	0.5	3.7	<0.1	<0.1	0.5

SOLUTION COMPOSITIONS:

	Pb (g/l)	Zn (g/l)	Cu (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Na (g/l)	Cl (g/l)	HCL (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
SX FEED	6.3	44.5		51.5	47.7			9.5	9.4	2.3
BARREN SOL/N	6.1	14.2		53.7	51.0			0	8.9	2.9
LOADED STRIP										
STRIP FEED										

SOLUTION SPECIFIC GRAVITIES:

SETTLER NO.	ORGANIC	AQUEOUS
1	0.974	1.216
2	0.978	1.238
3	0.988	1.253
4	0.989	1.093
5	0.989	1.079
6	0.977	1.072
7	0.971	1.060
8	0.966	1.051
9	0.961	1.037

SOLVENT EXTRACTION TEST: D6-15 DATE: Mar. 6/85

SOLUTION FROM TEST: D5-29
SOLUTION WEIGHT: 15.2 kg sg. 1.32
VOLUME: 11.5

SX CONFIGURATION:

	Stages	O/A	Flow (ml/min.)
Extraction	3	2½/1	85/35
Scrub	1	5/1	85/16
Strip	5	2/1	85/42

DISTRIBUTION AT 240 MIN.:

	1A	3A	3O	4A	5A	9A	9O
Zn (g/l)	11.7	35.7	47.8	46.1	47.4	23.1	15.0
Pb (g/l)	7.6	7.5	-	0	0	0	-
Fe (g/l)	60.0	60.4	-	6.6	0	0	-

SOLUTION COMPOSITION:

	Pb (g/l)	Zn (g/l)	Fe (g/l)	Fe^{2+} (g/l)	Ag ppm	SO_4^{2-} (g/l)
SX Feed	7.3	51.3	59.7	54.4	0.68	13.3
Barren Sol.	11.9	13.6	58.1	54.6	1.12	13.8
Loaded Strip	0.031	48.9	0.7	41	0.76	0.1
Strip Feed	-	15.0	-	-	-	-
Loaded Scrub	0	46.5	6.0	3.2	0.52	0.4
Scrub Feed	-	40.0	-	-	-	-

SOLVENT EXTRACTION TEST: D6-15

SPECIFIC GRAVITIES:

CELL #.	ORGANIC (kg/l)	AQUEOUS (kg/l)
1	0.971	1.257
2	0.979	1.282
3	0.989	1.304
4	0.988	1.096
5	0.982	1.077
6	0.976	1.066
7	0.971	1.053
8	0.965	1.044
9	0.961	1.032

STRIPPING SOLUTION (15 gpl)

In = 1.018 kg/l
Out = 1.080 kg/l

SCRUB SOLUTION (40 gpl)

In = 1.060 kg/l
Out = 1.100 kg/l

FEED SOLUTION: 1.319 kg/l

RAFINATE: 1.258 kg/l

D7-02

TURBOAERATOR TEST: D7-02

DATE: 02/19/85

SOLUTION FROM TEST: D6-05

VOLUME: 1.0 l sg: 1.2227 g/cc

TEMPERATURE: 85°C

AGITATOR rpm: 1823

O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	56.8	53.9
15	55.4	53.5
30	54.3	48.7
45	55.9	46.7
60	54.8	42.8
75	52.4	37.8
90	50.2	34.6
105	30.6	33.0
120	49.0	30.2

FINAL FILTERATE VOLUME: 0.665 l

FILTERED SOLID: 0.020 kg

TOTAL SOLIDS: 0.018 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.3	4.5	0.13	63	169	10.1	19.7
120	5.3	4.5	0.16	64	173	3.73	19.8

D7-03

TURBOAERATOR TEST: D7-03   DATE: 02/20/85

SOLUTION FROM TEST: D6-05
VOLUME: 1.0 l   sg: 1.2218 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1304
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	55.9	54.7
15	55.6	53.5
30	55.9	51.3
45	53.2	47.0
60	54.0	45.3
75	53.5	42.1
90	52.6	39.7
105	51.8	37.3
120	50.5	32.8

FINAL FILTERATE VOLUME: 0.698 l
FILTERED SOLID: 0.018 kg

TOTAL SOLIDS: 0.015 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.4	4.2	0.06	62	174	10.1	20.6
120	5.5	4.4	0.10	62	167	5.62	21.9

04

TURBOAERATOR TEST: D7-04 DATE: 02/21/85

SOLUTION FROM TEST: D6-05
VOLUME: 1.00 l sg: 1.2223 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1553
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	54.7	52.6
15	54.7	53.8
30	55.3	49.3
45	53.8	46.0
60	53.8	42.8
75	51.2	37.9
90	46.7	33.0
105	47.7	31.8
120	47.9	27.7

FINAL FILTERATE VOLUME: 0.700 l
FILTERED SOLID: 0.020 kg

TOTAL SOLIDS: 0.017 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.3	4.2	0.09	61		10.6	18.1
120	5.5	4.5	0.12	63	179	3.51	19.8

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
9.8	29.3	37.2

D7-05

TURBOAERATOR TEST: D7-05   DATE: 02/22/85

SOLUTION FROM TEST: D6-05

VOLUME: 1.0 1   sg: 1.2231 g/cc

TEMPERATURE: 85°C

AGITATOR rpm: 2029

0_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/1)	Fe^{2+} (g/1)
0	61.4	52.6
15	55.5	53.4
30	53.9	50.3
45	54.2	45.3
60	54.5	41.7
75	52.8	37.5
90	50.9	34.4
105	49.9	31.8
120	47.9	27.2

FINAL FILTERATE VOLUME: 0.665 1

FILTERED SOLID: 0.030 kg

TOTAL SOLIDS: 0.021 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/1)	Zn (g/1)	Cu (g/1)	Na (g/1)	Cl (g/1)	SO_4^{2-} (g/1)	Ag (ppm)
0	5.6	4.2	0.10	60	168	9.15	19.2
120	5.8	4.4	0.09	64	175	3.20	22.6

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
8.0	24.1	33.1

TURBOAERATOR TEST: D7-06 DATE: 02/23/85

SOLUTION FROM TEST: D6-05
VOLUME: 1.0 l sg: 1.2241 g/cc
TEMPERATURE: 80°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	55.5	53.2
15	55.5	53.2
30	55.4	47.8
45	54.8	46.0
60	52.3	40.9
75	50.4	35.5
90	50.0	33.3
105	46.3	29.2
120	48.2	29.2

FINAL FILTERATE VOLUME: 0.667 l
FILTERED SOLID: 0.026 kg

TOTAL SOLIDS: 0.017 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.6	4.2	0.11	61	166	9.82	19.9
120	5.7	4.3	0.06	64	173	3.93	20.7

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
9.3	27.8	37.4

TURBOAERATOR TEST: D7-07 DATE: 02/25/85

SOLUTION FROM TEST: D6-05
VOLUME: 1.0 l sg: 1.2231 g/cc
TEMPERATURE: 90°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	56.1	55.4
15	57.0	51.8
30	55.3	45.6
45	53.5	41.4
60	49.2	35.0
75	51.0	34.1
90	50.5	31.3
105	47.2	27.5
120	48.1	25.6

FINAL FILTERATE VOLUME: 0.735 l
FILTERED SOLID: 0.022 kg

TOTAL SOLIDS: 0.019 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.4	4.1	0.08	60	167	10.0	9.76
120	7.4	4.5	0.07	64	177	1.95	21.0

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
10.3	30.9	38.0

TURBOAERATOR TEST: D7-08 DATE: 02/28/85

SOLUTION FROM TEST: D6-05
VOLUME: 0.940 l sg: 1.2234 g/cc
TEMPERATURE: 75°C
AGITATOR rpm: 1833 rpm
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	57.4	55.0
15	55.8	51.6
30	56.9	48.3
45	55.8	44.1
60	54.0	41.2
75	50.9	36.3
90	51.6	35.5
105	51.3	33.4
120	50.7	31.7

FINAL FILTERATE VOLUME: 0.650 l
FILTERED SOLID: 0.024 kg

TOTAL SOLIDS: 0.014 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.3	4.1	<0.01	60	168	8.54	18.0
120	5.6	4.1	<0.01	59	172	5.79	19.7

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
7.7	23.0	40.5

TURBOAERATOR TEST: D7-09 DATE: 02/28/85

SOLUTION FROM TEST: D6-09
VOLUME: 0.940 l sg: 1.2232 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 183 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	54.7	52.5
15	55.5	50.6
30	55.1	47.1
45	54.0	42.7
60	53.7	40.6
75	51.7	35.7
90	50.2	32.5
105	49.2	30.3
120	49.0	28.4

FINAL FILTERATE VOLUME: 0.635 l
FILTERED SOLID: 0.019 kg

TOTAL SOLIDS: 0.018 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	5.4	3.9	<0.01	57		9.99	18.2
120	5.7	4.3	<0.01	64	178	2.58	20.2

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
10.5	31.5	35.9

TURBOAERATOR TEST: D7-10

DATE: 02/28/85

SOLUTION FROM TEST: D6-09
VOLUME: 0.940 l sg: 1.2312 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	59.9	58.2
15	58.0	49.7
30	54.8	43.2
45	51.9	36.2
60	50.0	31.1
75	47.5	28.4
90	47.0	24.8
105	46.5	21.8
120	46.2	19.7

FINAL FILTERATE VOLUME: 0.640 l
FILTERED SOLID: 0.073 kg

TOTAL SOLIDS: 0.043 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	8.9	12.0	<0.01	72	193	12.2	28.0
120	9.8	12.8	<0.01	79	206	3.25	29.4

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
6.1	18.4	37.8

FINAL FILTERATE VOLUME: 0.670 l
FILTERED SOLID: 0.050 kg

TOTAL SOLIDS: 0.027 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	9.2	12.6	0.04	76	199	12.1	29.9
120	8.8	13.3	0.04	81	210	5.19	33.0

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
10.3	30.7	33.2

TURBOAERATOR TEST: D7-11 DATE: 02/28/85

SOLUTION FROM TEST: D6-09
VOLUME: 0.940 l sg: 1.2313 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	61.8	54.9
15	58.3	47.6
30	55.7	39.3
45	53.0	32.1
60	52.1	29.0
75	49.6	28.0
90	47.9	22.8
105	46.3	19.7
120	48.3	20.8

FINAL FILTERATE VOLUME: 0.605 l

FILTERED SOLID: 0.056 kg

TOTAL SOLIDS: 0.033 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	9.2	12.4	0.04	77	197	12.9	29.9
120	9.9	13.6	0.04	78	207	2.79	32.1

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
8.1	24.1	36.2

TURBOAERATOR TEST: D7-12 DATE: 01/03/85

SOLUTION FROM TEST: D6-09

VOLUME: 0.940 l sg: 1.2121 g/cc

TEMPERATURE: 85°C

AGITATOR rpm: 1833

O_2 FLOW RATE: 71 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	62.0	55.8
15	62.6	53.8
30	58.3	45.5
45	56.0	40.4
60	54.0	35.2
75	51.8	31.0
90	50.4	26.9
105	52.0	25.9
120	47.5	21.2

TURBOAERATOR TEST: D7-15 **DATE:** 03/04/85

SOLUTION FROM TEST: D6-09
VOLUME: 0.940 l **sg:** 1.2123 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	63.9	59.4
60	54.0	37.8
120	47.3	24.1
180	46.4	16.5
240	44.6	12.4
300	43.0	9.4
360	46.0	8.3

FINAL FILTERATE VOLUME: 0.699 l
FILTERED SOLID: 0.079 kg

TOTAL SOLIDS: 0.056 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0					202	13.9	30.9
360	9.7	13.4	0.06		210	1.06	34.6

FILTERED SOLID COMPOSITION:

TIME (Hrs)	S %	SO_4%	Fe %
1		22.8	27.9
2		28.1	40.9
3		26.9	41.2
4		25.5	41.3
5		24.5	41.8
6	6.1	18.3	32.8

TURBOAERATOR TEST: D7-16 DATE: 03/08/85

SOLUTION FROM TEST: D6-14

* VOLUME: 2.00 l sg: 1.2313 g/cc

TEMPERATURE: 85°C

AGITATOR rpm: 1833

O_2 FLOW RATE: 370 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	52.6	50.3
240	41.2	15.3

* Used in settling test 13#.

FINAL FILTERATE VOLUME: *

FILTERED SOLID: .057 kg

TOTAL SOLIDS: .032 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	6.39	13.9	0.03	64.0	181	9.09	3.68
240	6.88	14.4	0.03	65.3	182	1.30	3.92

FILTERED SOLID COMPOSITION:

S%	SO_4%	Fe%
8.4	25.3	41.1

* Used unfiltered in settling test # 13.

TURBOAERATOR TEST: D7-17 **DATE:** 03/13/85

SOLUTION FROM TEST: D6-15
VOLUME: 0.940 l sg: 1.2314 g/cc
TEMPERATURE: 85°C
AGITATOR rpm: 1833
O_2 FLOW RATE: 218 ml/min

OXIDATION RESULTS:

TIME (min)	Fe - TOTAL (g/l)	Fe^{2+} (g/l)
0	58.3	57.0
60	54.9	56.1
120	42.0	47.8
180	40.5	20.6
240	36.0	14.1
300	37.8	9.2
360	38.9	6.7

FINAL FILTERATE VOLUME: 0.650 l
FILTERED SOLID: 0.061 kg

TOTAL SOLIDS: 0.037 kg

SOLUTION COMPOSITIONS:

TIME (min)	Pb (g/l)	Zn (g/l)	Cu (g/l)	Na (g/l)	Cl (g/l)	SO_4^{2-} (g/l)	Ag (ppm)
0	8.04	12.0	0.04	80.8	202	9.09	1.0
360	10.7	12.8	0.03	83.6	213	1.30	0.96

FILTERED SOLID COMPOSITION:

TIME (hrs)	SO_4 %	Fe %
1	3.9	18.7
2	15.2	28.8
3	16.9	29.5
4	15.4	27.5
5	16.2	28.8
6	25.3	42.3